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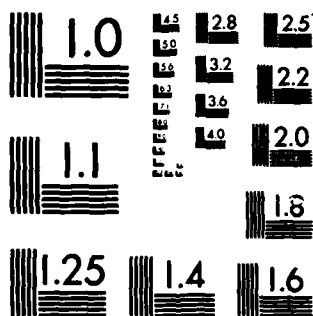UNCLASSIFIED   M D GAUTHIER-MAYER NOV 85 DRES-SP-97   F/G 9/2   NL

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PLOT: A BASIC PLOTTING ROUTINE FOR THE

TEKTRONIX 4054 TERMINAL AND 4663 PLOTTER (U)

by

M.D. Gauthier-Mayer

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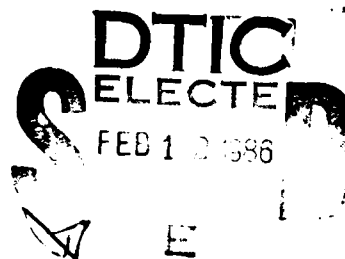DEFENCE RESEARCH ESTABLISHMENT SUFFIELD
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ABSTRACT

`A BASIC plotting routine for the Tektronix 4054 terminal and 4663 plotter has been developed. It is named PLOT. The program is capable of plotting in a variety of coordinate systems - Cartesian, semilog on X, semilog on Y or log-log. Two separate Y axes can be used. The user can input the axes boundaries, axes titles, the block of data to be plotted, legends for the data, and a figure caption. Model equations can be represented by dashed lines on the plot. The program will accommodate up to 70 data sets, and a total of six data columns. The data can be manipulated by changing data points or sets, adding sets and columns, deleting sets or columns, sorting data in a column, generating columns from existing data and adding two data files together. This report is a working manual for the PLOT program.

ACKNOWLEDGEMENTS

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INTRODUCTION

1.   There is a continuing need in the physical chemistry group at DRES
to produce a variety of graphs, quickly and in a publishable format.
To meet these requirements, a BASIC plotting program was written for
use with the Tektronix 4054 terminal and the 4663 plotter. Several
Tektronix manuals were used as references for the program[1-5]. The
program has the capability of producing plots in log-log, semilog or
Cartesian coordinates. It is entitled PLOT, and allows the user to
input data into an array, choose the type of plot required, and plot
all or part of the data. This report is designed as a user's guide to
the program.

2.   The data is entered into an array, dimensioned for 70 data sets
and 6 columns of data. The data can be manipulated in several ways.
Individual points or data sets can be changed. Data sets or columns
can be deleted. Data may be added as sets or columns. Columns can

be generated (through an equation) from existing data. The data can be sorted, using any column. The data can be stored in a file on tape. As well, two data files can be added together to form one file.

3.   The plotting routine allows the user to plot any column as X, and any column as Y, in the coordinate system of his choice - Cartesian, semilog on X, semilog on Y or log-log. The user can also have a second Y axis, along the right hand side of the graph (called the Z axis). Any column can be chosen as Z, and the axis type can be different from the Y axis. The user determines the range of the X, Y and Z axes and which points are to be plotted in the X,Y or X,Z plots. The data can be plotted with axes, or without. After plotting, a least squares fit of the plotted data is calculated (for X,Y and X,Z data) and the user has the option of plotting the best straight line through the data. The equation of the line is displayed on the screen. The user can input a legend to identify the plotting symbols, and a title or figure caption. As well, the user has the option to input an equation, or model, as a function of the X data, and plot the resulting curve with a dashed line pattern. Once a plot is satisfactory, it can be repeated any number of times - either on the screen, or on the plotter.

4.   The data can be listed on the screen or on a printer (such as a Datacom 1200 terminal). For the printer, the user can list the data with a different number of significant figures for each column. The columns of data are centered for an 8½ x 11 sheet of paper. The resulting list is in publishable format, although column headings and a table number must be added.

5.   This report is a working guide to the PLOT program. Each section

describes a particular routine, and how to use it. The program is designed to be versatile and can accommodate a wide range of plotting needs. However, it can be tailored by the user to meet specific requirements. Suggestions for such changes are included wherever possible. Appendix I contains the USER KEY assignments, Appendix II documents the variables used in the program, and Appendix III lists the sizes of the arrays in the program. A hard copy of the program is in Appendix IV. The required set ups for the DATACOM 1220 printer and the Tektronix 4663 plotter are in Appendix V and Appendix VI, respectively.

STORAGE REQUIREMENTS

6.   The program is in File 1 of the tape. The file length is 65024 bytes, of which the program uses 40585 bytes. After loading the program into the Tektronix 4054 terminal, there are ~ 7200 bytes of memory remaining. About 1000 bytes are required for variables in the different routines. The remainder is available for data storage.

7.   The data is stored in an array, A. The size of A is limited by the number of bytes (~ 6200) available in the memory. The array is dimensioned for 70 data sets and six columns of data. If the user has more than 70 sets, or 6 columns, then the data must be split into two data files.

STARTING THE PROGRAM

8.   Insert the program tape, entitled PLOT, into the terminal. To input the program into memory and start it, use the AUTOLOAD button[2], or the following procedure:[2]

a.   Find the file the program is stored in. FIND 1 (return)

    b.   Load the program. OLD (return)

    c.   Start the program. RUN (return)

9.   At the start of the program, the terminal settings are initialized and the variables are dimensioned. Many of the variables are set to their default values. The screen displays the name of the program and is ready for data input (see DATA ENTRY).

10. Once the program has been loaded, USER KEY #1 will also restart the program. This will eliminate any previous data though and reset all the parameters to their initial values.[2]

DATA ENTRY (USER KEY #1)

11. Data is entered from a file on a data tape, or from the keyboard.

    a.   *Tape entry* - the user is asked to insert the data tape, and input the file number containing the data. The input read from the tape is:

        (1) S1, number of sets of data

        (2) V1, number of columns of data

        (3) sets of data

        (4) S$, data identification (if applicable)

        The data identification and the data sets are automatically listed on the screen, once the tape input is finished.

Note: The data identification is not always in the data file, especially with older data files. If it is not found in the file, the data identification is requested by the program.

b. Keyboard entry - the user is asked to input
(1) data identification (S$)
(2) number of columns (V1)
(3) number of data sets (S1)
(4) data sets
A bell will sound at the end of the data entry, when S1 data sets have been input.

12. The data is stored in the array A. The array is dimensioned for 70 data sets and six columns. If the number of user data sets (S1) exceeds 70, or the number of user columns (VI) exceeds 6, then only part of the data will be read in - enough to fill the array. The memory of the 4054 is not large enough to accommodate a larger array, without a memory error. The remaining data must be entered through the keyboard into another file, or some of the data must be deleted to accommodate it.

13. If there are more data sets to enter, use USER KEY #3, adding sets of data. Otherwise the data can now be listed (USER KEY #2), modified through deletions or changes, or plotted (USER KEY #9).

Note: In some cases there may be several columns of data, but not all columns are full of data. However, all data sets must have a number in each column. It is not advisable to put a zero in blank spots, as this will cause an error in any log plots involving this column (log 0 is undefined). The number 1E-10 should be used. This will also facilitate the data listing, when done in scientific notation on the printer (see DATA LIST).

DATA LIST (USER KEY #2)

14. This can be used for listing data on the screen, or on the printer.

    a.   Screen Listing - the output format is -5D.3D, which results in a maximum of 5 digits left of the decimal point and 3 digits to the right[1] (program line 1220). If the number is larger than 10^6 or smaller than 10^{-3}, the format is 3E (scientific notation, with three digits right of the decimal point, line 1240). Values of 1E-10 (i.e., zero values) are printed as ' - '.

    b.   Printer Listing - two format types are possible. The printer set-up is described in Appendix V. The user is asked 'Is scientific notation format required? (Y or N)'.

        (1) Yes - the scientific notation format allows the user to have a different number of significant figures (3 to 6) for each column. This is especially useful for printing tables of data for publication. The format statements are in lines 10540 to 10770. If the program encounters a value of 1E-10 (i.e., a blank) then a '-' is printed, indicating that no value is available. The columns are spaced to fit on an 8½" wide page. Table I is a sample printer output using the scientific notation format.

Note: The scientific notation formats for the printer are designed for 5 or less columns of data. The formats must be changed if more columns are required.

(2) No - the printer output is the same as the screen output above. That is the format is -5D.3D, unless the number is larger than 10^6 or smaller than 10^{-3}, in which case the format is 3E. Values of 1E-10 are printed as ' - '. Table II is a sample printer output using the screen format.

Note: Any of these formats can be changed to fit a specific requirement. The formats written into the program were for general usage.

ADDING SETS OF DATA (USER KEY #3)

15. When the program is started, the initial number of data sets (S1) is input with the data. The array is dimensioned for 70 data sets. If S1 is less than 70, then more data sets can be added. When USER KEY #3 is pressed, the screen shows the number of additional sets that are allowed. Input from the user is:

a. number of sets to be added
b. input data after set number? This allows the new data to be placed anywhere in the data array.
c. input additional sets. Each data set must have the same number of columns (V1) as the original data.

16. The new data set is then listed on the screen.

ADDING COLUMNS OF DATA (USER KEY #4)

17. When the program is started, the initial number of columns (V1) is input with the data. The data array is dimensioned for six columns of data. If V1 is less than 6, then additional columns may be added. For each new column, there should be S1 data points, so every data set has a number in each column. There should be no blanks in the new columns. If there is a blank, use 1E-10 instead of zero (see DATA LIST Section).

18. The user is asked for:
    a. the number of additional columns
    b. the data. For two additional columns, the two values for the first data set are entered, then the two for the second data set, etc.
The data is listed automatically at the end of the new data entry.

CHANGING DATA (USER KEY #5)

19. This is used to change either individual data points, or a whole row (set) of data.
    a. data points
        (1) input the data set number to be changed
        (2) input the column number
        (3) input the new data point
    b. sets of data
        (1) input the data set number to be changed
        (2) input the new row.
There must be a value in each column of the row.

Note: To stop either type of change routine, press the carriage return twice.

DELETING DATA SETS (USER KEY #6)

20. This is used to delete data sets, either individually or in a block. For both types of deletion, all the sets to be deleted are input, then a carriage return with no set number stops the input. At this point, no deletions have occurred, but all the set numbers are stored in the array, E. The sets are sorted by set number, and the deletions start at the highest set number. Thus the set numbers to be deleted can be input randomly.

Note: If an incorrect set number, or block of sets has been input for deletion, the deletions can be cancelled by pressing the BREAK key. This must be done BEFORE the sorting routine has started though. Also note that this will cancel ALL deletions.

   a. Deleting single sets
     (1) input the set number to be deleted
     (2) the values in the deleted set are printed on the screen
     (3) the user is asked for the next set to be deleted

   b. Deleting a block of sets
     (1) input the first set number of the block, and the last set number of the block
     (2) the first and last set numbers for the block are printed on the screen.
     (3) the user is asked for the first set number of the next block to be deleted

After the deletions, the remaining data sets (renumbered) are listed on the screen. The value of S1 (number of sets) is updated.

DELETING DATA COLUMNS (USER KEY #7)

21. This is used to delete a whole column of data at once. The user is asked to input the column number to be deleted. The column is deleted and the remaining data is printed on the screen. Note that there is no way to stop the deletion, once the column number has been input.

SORTING ROUTINE (USER KEY #11)

22. The sorting routine allows the user to choose a column, which is then sorted by value, with the highest value placed first. Any column can be sorted. The data in the other columns is automatically moved too, to ensure that each data set stays intact. The sorting routine is useful when the data has been input randomly, but should be in order before listing on the printer. This routine can be used any number of times. The sorted data is printed on the screen at the end of the routine.

STORING DATA ON TAPE (USER KEY #8)

23. This option is used if the data was input through the keyboard, or the data has been altered.

   a. The program states the minimum number of bytes required for the data in the file. The file should be marked with this number of bytes.[2]

b. The data tape is then inserted (arrow in the UNSAFE position).[2]

c. The user inputs the file number for storage of the data. If there is not enough room in the file, error message 48[1] will result.

24. The data is stored on the tape in the following order:

a. *number of sets (S1) and number of columns (V1)*

b. *data sets (array A)*

c. *data identification (S$)*

25. The data tape is removed then, to prevent accidentally writing on it.

Note: The data tape should be secured by putting the arrow to the SAFE position.[2] In this position, the tape can be read only, not written on.

GENERATING A COLUMN FROM DATA (USER KEY #12)

26. This option allows the user to generate a column of data using the existing data, by inputing a transformation equation. The column to be transformed is written in array format, i.e., A(I,n) where n is the column number used in the transformation. The equation is input by recalling line 10260, and changing the RIGHT HAND SIDE of the equation.

$$i.e. \ 10260 \ A(I, \ V1+1)=A(I,4)*10$$

As written in the program, column 4 is multiplied by ten to generate a new column. The right hand side of the equation is changed according to the transformation required.

27. The new column is generated by pressing USER KEY #13.

Note: A second column can be generated at the same time by adding
      another line at 10265, similar to 10260, with the second
      transformation. Use the notation
                   10265 A(I, V1+2)=A(I, V1+1)/2.2
                   10280 V1 = V1+2

Note: Using this routine to generate two columns at once should be used
      with caution. The array is only designed to hold six columns.
      If more are attempted, a dimension error will result.

28. All data will be listed on the screen automatically.

ADDING TWO FILES OF DATA (USER KEY #16)

29. Two files of data, with the same number of columns, may be added
to form one large file. However, the total number of data sets cannot
exceed 70, or a dimension error will result. There are two options -
data may be added to the current file of data, or two data tape files
may be added together. If two tape files are added together, the
current data in memory is erased.

      a. Adding to the current file -
         (1)   the user is asked to insert the data tape containing the
               second file, and input the file number.
         (2)   the number of sets, number of columns and the data from
               this file is read in.

(3)   then one large array is formed containing both sets.

(4)   the user is asked to input the data identification (S$) for the new file.

(5)   the new data is then printed on the screen.

b. Adding two data tape files –

(1)   the first tape is inserted and the file number input

(2)   the number of sets, number of columns and the data is read from this file

(3)   the second tape is inserted and the file number input

(4)   the number of sets, number of columns and the data is read from this file

(5)   one large array is formed

(6)   the user is asked to input the data identification (S$)

(7)   the data is listed on the screen.

It is a good idea to store the new data on a tape now.

Note: The routine will end if the two files of data do not have the same number of columns. The number of columns can be changed by deletion, adding a column, or generating a column.

PLOTTING AXES AND DATA (USER KEY #9)

30. This is the main plotting routine. The program is capable of plotting Cartesian coordinates, semilog on X, semilog on Y or log-log plots. Two separate Y axes are allowed. The user inputs the boundaries for the axes, the axes titles, and the data points to be plotted. There is also an option for printing a legend and a figure title. A typical plot is shown in Figure 1.

31. There is a choice of symbol size, symbol type (seven different ones) and output device (screen or plotter). A least squares fit is calculated for all plots, with the option to plot the best straight line through the data. This is only relevant, though, for linear plots. As well, the user has the option to input an equation to calculate Y values from X data. The calculated Y vs X will be plotted as a dashed line.

32. The user is asked several questions before the plot is finalized. The input is outlined in the following paragraphs. The set-up required for the plotter is detailed in Appendix VI.

33. Are two separate Y axes required? Two separate Y axes (Y and Z) are used, on occasion, with a common X axis. If this option is chosen, further information about the X, Y and Z axes are required. Otherwise, only the X and Y axes are dealt with.

34. Enter the X column number and the Y column number (and the Z column number if required).

35. Select the plot type for X, Y plot
    (a)   Cartesian
    (b)   semilog (log along X)
    (c)   semilog (log along Y)
    (d)   log-log

36. For an X, Y, Z plot, the Z axis can be the same as the Y axis, or different. The user then chooses for Z either
    (a)   Cartesian axis, or
    (b)   log axis

Note: When the axis types are selected, the corresponding columns, as a whole, are processed. For a log axis, all of the numbers in that column are transformed to log values, in anticipation of the plot. It is essential that the data be in the correct format at this stage, or error message 23 will result[1]. There should be no zeros in the data, if log axes are selected (log $\emptyset$ is undefined).

37. Draw axes and data or data only? Usually, both axes and data are drawn first. Other data can be added later then, with the data only option.

38. Input titles for X, Y (and Z) axes. For each axis, either upper or lower case letters or any characters can be used. The maximum number of characters (including blanks) is 50. The titles are automatically centered about the corresponding axis. Titles with subscripts and superscripts can be handled using the CTRL K and CTRL J characters (i.e. holding the CTRL and K or J keys at the same time)[1]. For example, the following title:

<center>SHEAR RATE (sec^{-1})</center>

would be input as:

<center>SHEAR RATE (sec CTRL K -1 CTRL J).</center>

In this example, the CTRL K moves the pen up one line so the -1 appears as a superscript. The CTRL J moves the pen down one line so the end bracket is properly aligned. Subscripts would be input in a similar manner, using CTRL J, then CTRL K.

Note: If multiple plots are being produced, with the same axes titles, it is more convenient to delete the lines inputing the titles and enter titles directly into the program. To do this, delete lines 4240, 4250, 4260 and 4270 (also 4290 and 4300 for Z axis). Then insert the titles as follows:

4240 X$= "_____" (chosen title for X axis)
4260 Y$= "_____" (for Y axis)
(4290 W$= "_____"(for Z axis))

The titles will remain in memory as long as the machine is on and the program is not reloaded into memory.

39. Input the first and last set numbers to be plotted
    (a)   for X,Y plot
    ((b) for X,Z plot)
    All of the data can be plotted, or any fraction of it.

40. Input a legend and title. The user has three options for the legends and titles.

    (a)   No legend
    (b)   New legend. If this option is chosen, the plot will be displayed automatically on the screen, at the end of the selection process. The user inputs the legend and title when the two crosshairs appear on the screen at the end of the plot.
    (c)   Old legend. The legend that is memory will be printed after the plot has been displayed, on either the screen or the plotter. The user cannot change it at all. If this option is selected, and there is no legend in the memory, then it is as if the "No Legend" option had been chosen.
          The legends and titles input is more fully explained under the LEGENDS AND TITLES routine.

41. Selection Menu Routine - this allows the user to choose the symbol size, the output device, the symbol type, and the dashed line option.

- (a) Symbol Size. This is a multiplier to the symbol size. The default is one. Values < 1 will result in smaller symbols while values > 1 will yield larger symbols.
- (b) Output device. This is where the plot will be drawn. The choices are:
  - (1) Screen - used initially to check the plot for any errors
  - (2) Plotter - used for the final output
- (c) Symbol type. There are seven different symbol types to choose from.
  - (1) triangle (default)
  - (2) square
  - (3) diamond
  - (4) cross
  - (5) X
  - (6) star
  - (7) dot

  The symbol type is chosen for the X, Y plot, then (if necessary) for the X, Z plot.

Note: When plotting data, sometimes it is convenient to use more than one symbol type for the data i.e., a star inside a box or a dot inside a triangle. This is done by plotting with one symbol, then repeating the plot (or drawing data points only) with the second symbol.

- (d) Dashed lines on a plot. This is used for drawing fitted curves. The equation for the curve is input by the user.

The options are

(1) no dashed line

(2) dashed line on the X,Y graph

((3) dashed line on the X,Z graph)

Note: It is important to distinguish between the X,Y and the X,Z graphs, so the dashed line is positioned properly.

If a dashed line is selected, there are three different dash patterns for the plotter. (There is only one for the screen _ _ _).

(1) _ _ _

(2) _._._._.

(3) ....

Note: More than one set of dashed lines can be plotted on a single graph, by using the PLOT DATA ONLY option (USER KEY #10).

The equation of the dashed line is imput in line 14890. It is of the form N=f(R), where R is the X column data and N is the generated Y component.

i.e. 14890 N(I)=R(I)*1.5

In this example, the X data (R(I)) is multiplied by 1.5 to generate the Y data (N(I)).

To input the dashed line equation

(1) recall line 14890

(2) change the right hand side of the equation

(3) press USER KEY #18

(e) END Selection - The selection menu reappears after each choice, until END Selection is chosen.

42. At this point, all the selections have been made and the graph is ready to be plotted. The plot is drawn in the following manner:

    (a)   bottom X axis and tic marks

    (b)   top X axis and tic marks

    (c)   left Y axis and tic marks

    (d)   right Y axis (or Z axis) and tic marks

    (e)   numbering the Z axis

    (f)   numbering the X axis

    (g)   numbering the Y axis

    (h)   labelling the X axis

    (i)   labelling the Y axis

    (j)   labelling the Z axis

    (k)   drawing the X, Y data points

    (l)   calculation of best straight line through the X,Y data

    (m)   drawing the X,Z data points

    (n)   calculation of the best straight line through the X,Z data

    (o)   drawing the dashed line (if selected)

    (p)   printing any legends or titles (if selected) or accepting input of new legends and titles

A typical plot is shown in Figure 1.

43. The program calculates the best straight line through the X, Y data using a least squares routine. The user has the option of

    a. plotting the line (on the chosen output display) and printing the equation (on the screen only),

    b. printing the equation only, on the screen

    c. neither

The best straight line is calculated, no matter what the shape of the curve. It only has meaning, though, for a linear plot. The best straight line through the X,Z data points is also calculated, and the options for printing are the same as for the X, Y data.

44. If the "Old Legend" option was selected, it is printed on the plot, at the end of the plotting routine. If the "New Legend" option was selected, two crosshairs now appear on the screen, waiting for input. The input for this is fully described in the section LEGENDS AND TITLES.

45. Once the graph has been completed, the user can repeat the graph, using the same parameters, by selecting the REPEATING A PLOT option (USER KEY #19). Otherwise, more data can be added to the graph by using the PLOTTING DATA ONLY option (USER KEY #10).

LEGENDS AND TITLES

46. This section describes how to input the legends and titles, if the "New Legend" option was selected. If this was selected, the plot will be displayed on the screen only - not on the plotter. Two crosshairs will appear on the screen at the end of the plot, awaiting input. There are also two grids superimposed on the plot for convenience:
   a. below the X axis title, for the figure caption
   b. at the top third of the axes grid, for the legend
The crosshairs can be positioned anywhere on the screen, not only where the grid lines appear.

47. To input a legend, position the two crosshairs to the desired location on the graph. The type of input at this position is governed by the key pressed. The key selections are as follows:
   a. 0 - writing only, no symbols. When this is selected, a question mark appears, waiting for alphanumeric input. The input is stopped when the carriage return is pressed.
   b. 1 - triange

    c. 2 - square

    d. 3 - diamond

    e. 4 - cross

    f. 5 - X

    g. 6 - star

    h. 7 - dot

    i. 8 - correct last entry. Pressing the 8 key erases the previous entry, entirely. If the previous entry was a symbol, it is erased from memory (but not from the screen display). If the previous entry was a line of writing, the whole line of writing is erased from the memory.

    j. 9 - end of input. The crosshairs disappear when 9 is pressed.

Note: For option 0, the writing appears slightly above the horizontal cursor. However, for options 1-7, the symbols are centered around the intersection of the two crosshairs.

Note: It is easy to forget to press 0 when writing only is required. Then, the crosshairs remain until one of the 10 keys specified above is pressed. If the 9 key is pressed, then all input stops. To get around this problem, press USER KEY #17, and reinput all the legend and title information.

48. USER KEY #17 can be used to delete the old legend, and input a new legend. This is particularly useful when a typing error occurs or when the input was accidentally stopped, as described in the note above. Once USER KEY #17 is pressed the memory is cleared of the previous legend and title information. The two grids appear, and the two crosshairs. While this key can be pressed anytime, it is a good idea to only use it when plot is displayed on the screen, especially if writing/symbols are required outside of the grids.

49. The grids are displayed only for convenience in aligning the alphanumeric input.   They are not displayed when the "OLD LEGEND" option is selected, and the legend in memory is printed.

50. Each grid has room for 5 lines of writing.   To use the grid, position the vertical crosshair, place the horizontal crosshair on one of the horizontal grid lines, press $\emptyset$, then input the line of writing. For symbols, line the horizontal crosshair half way between two horizontal grid lines, then press the desired symbol number.

REPEATING A PLOT (USER KEY #19)

51. If the identical plot to the last one is required (i.e., same axes, titles, and data points) then this option is used.   This is convenient when the plot is correct on the screen, and a plotter copy is required, or when more than one plotter copies are needed.   The user can change the items in the Selection Menu only.   That is:
    a. symbol size
    b. output device
    c. symbol type
    d. dashed line
There is also the option for plotting the best straight line through the data or not.

PLOTTING DATA ONLY (USER KEY #10)

52. Sometimes more than one set of data is required on a graph. Then, the Plotting Data Only option is used, after the 'initial' plot is finished, to add on other data points.   No axes are drawn with this option.

53. The user input is:

a. number of first and last data points to be plotted

b. the legends and titles option

c. selection menu for

   (1)   symbol size

   (2)   output device

   (3)   symbol selection

   (4)   dashed line

54. The data points are then plotted on the specified output device.
The use again has the option of:

a. plotting the best straight line on the output device and
    printing the line equation on the screen

b. printing the line equation on the screen only

c. neither

Next, any dashed lines are drawn, and the legends and titles are
printed.

55.   This option can be repeated any number of times, to plot all the
data needed for an axes set.

Note: If a zero is input for either the first or last number to be
      plotted, then no points are drawn, but the dashed line and
      legends will be plotted. This is useful if more than one dashed
      line is required on a graph. It is also useful if a legend is
      required, but it was not input when the axes were drawn.

CALCULATING Y OR Z FROM X, AFTER LEAST SQUARES CALCULATION
(USER KEY #14)

56. After plotting the X, Y data points, the program calculates the

best straight line through the data. The equation of the straight line can be used to calculate values of Y from X, with this routine. The values of Z can also be calculated from X, using the equation from the X, Z data. The goodness of the fit depends on the value of R^2, calculated in the least squares routine.

Note: USER KEY #14 should only be used after a plot has been made, and the least squares fit calculated for the current data.

57. The user input is:
   a. calculate Y or Z from X?
   b. list on screen or printer? Both X and the calculated Y (or Z) values are listed.
   c. input X values.

The routine stops with an empty carriage return. A sample output from the printer is listed in Table III.

CALCULATING X FROM Y OR Z, AFTER LEAST SQUARES CALCULATION
(USER KEY #15)

58. This routine calculates X, from either Y or Z, based on the equation of the best straight line through the data points (either the X, Y data or the X, Z data). The goodness of the fit depends on the value of R^2, calculated in the least squares routine.

Note: User Key #15 should only be used after a plot has been made, and the least squares fit calculated for the current data.

59. The user input is:
    a. calculate X from Y or Z?
    b. list on screen or printer? Both the Y (or Z) value and the
       calculated X value are listed.
    c. input Y (or Z) values

The routine is stopped with an empty carriage return. A sample output
from the printer is listed in Table IV.

REFERENCES

1.   Tektronix 4050 Series Graphic System Reference Manual, 1980
     Tektronix Inc., P.O. Box 500, Beaverton, Oregon, 97077

2.   Tektronix 4050 Series Graphic Computing System Operator's Manual,
     1980

3.   Tektronix Plot 50 Introduction to Programming in BASIC, 1980

4.   Tektronix 4663 Interactive Digital Plotter Operator's Manual, 1980

5.   Tektronix 4663 Interactive Digital Plotter Programmer's Reference
     Manual, 1982

TABLE I: SAMPLE PRINTER OUTPUT USING THE SCIENTIFIC NOTATION FORMAT

X	Y	Z
1.31E+002	4.785E+001	3.6634E-001
7.84E+001	3.006E+001	3.8356E-001
5.53E+001	2.168E+001	3.9211E-001
3.92E+001	1.556E+001	3.9714E-001
2.76E+001	1.116E+001	4.0371E-001
1.57E+001	6.383E+000	4.0726E-001
1.11E+001	4.588E+000	4.1494E-001

TABLE II: SAMPLE PRINTER OUTPUT USING THE SCREEN FORMAT

TEST DATA

1	130.611	47.848	0.366
2	78.366	30.058	0.384
3	55.283	21.677	0.392
4	39.183	15.561	0.397
5	27.641	11.159	0.404
6	15.673	6.383	0.407
7	11.057	4.588	0.415

TABLE III: SAMPLE PRINTER OUTPUT FOR Y CALCULATED FROM X, AFTER THE LEAST SQUARES CALCULATION

TEST DATA

```
X=131          Y EST=48.5731458317
X=78.4         Y EST=29.5025326632
X=55.3         Y EST=21.1274154733
X=39.2         Y EST=15.2902125833
X=27.6         Y EST=11.084526029
X=15.7         Y EST=6.77007171904
X=11.1         Y EST=5.10229946476
```

TABLE IV: SAMPLE PRINTER OUTPUT FOR X CALCULATED FROM Y, AFTER THE LEAST
SQUARES CALCULATION

TEST DATA

Y=47.85	X EST=129.005440601
Y=30.06	X EST=79.9375898853
Y=21.68	X EST=56.8241222634
Y=15.56	X EST=39.9441196565
Y=11.16	X EST=27.8081700698
Y=6.383	X EST=14.6323902571
Y=4.588	X EST=9.68147445982
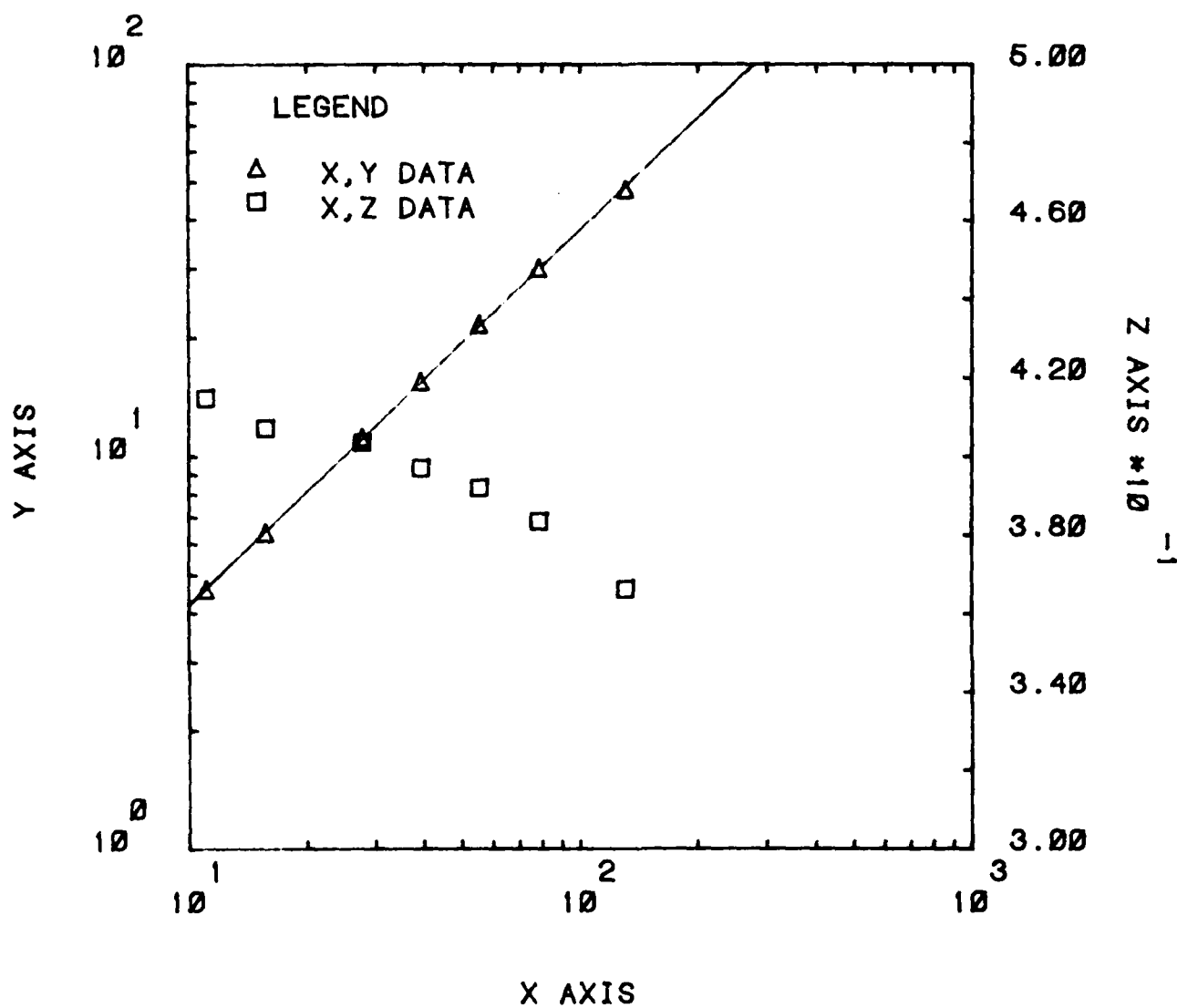
Figure 1

Typical plot obtained from the PLOT program, showing
the best straight line through the X,Y data.

USER KEY ASSIGNMENTS

#1 data entry (tape or keyboard)

#2 data list (on screen or printer)

#3 adding sets of data

#4 adding columns of data

#5 changing data (points or sets)

#6 deleting data sets (individually or in blocks)

#7 deleting data columns

#8 storing data on mag tape

#9 plotting data and axes

#10 plotting data only

#11 sorting routine

#12 generating a column from existing data

#13 continuation of column generation

#14 calculate Y or Z from X, after Least Squares Calculation

#15 calculate X from Y or Z after Least Squares Calculation

#16 adding two files of data (same number of columns)

#17 input Legend and Title

#18 continuation of dashed line on plot

#19 repeating a plot

VARIABLES USED   Appendix II

A   -   2-dimensional array used to hold all the data
A1   -   variable used when adding sets of data. It is the actual number of added sets.
A2   -   number of additional columns, when adding columns of data
A3   -   used in the least squares calculation
A4   -   symbol selection number for X,Z plot
A5,A6   -   used when calculating X from Y or Z (after least squares calculation) where A3=A6 for X from Y calculation
                            and   A3=A5 for X from Z calculation
A9   -   used in numbering the Z axis in Cartesian coordinates. When A9=0, there are no exponents in the axis numbers.
A$ -   symbol type associated with A4 in X,Z plot
B   -   2-dimensional array used for additional data sets when adding sets of data
B1   -   used in the least squares calculation
B3,B4   -   used when calculating X from Y or Z (after least squares calculation) where B1=B4 for X from Y calculation
                            and B1=B3 for X from Z calculation
C   -   1-dimensional array used for additional columns when adding columns of data
C1, C$ -   used for changing data points, indicates the column number
D   -   1-dimensional array used for initial input of data from the keyboard
D1, D$ -   number of set deleted, in the set deletion routine
D2   -   number of column deleted, in the column deletion routine
D3,D4   -   first and last sets to be deleted in the block deletion routine
D6, D7   -   used in the least squares calculation

E	- 1-dimensional array used in deleting data sets
E1	- used in deleting data sets
E4	- used to identify type of coordinate on Z-axis (E4=0 for Cartesian, E4=2 for log)
E$	- string storage for dashed line status
F, F1	- used in the least squares calculation
F2	- used to calculate Y from X (or X from Y) after the least squares calculations
F3	- file number for input data
F4	- used to sort data sets before deletions
F$	- value of X in calculating Y from X
G, G1	- used in the least squares calculation
G2	- used to calculate Y from X (or X from Y) after least squares calculations
G$	- value of Y in calculating X from Y
H	- 2 dimensional array to hold the legend and title data H(I,1)=type of input; H(I,2)=H4; H(I,3)=H3; H(I,4)=H1; H(I,5)=H2
H1	- initial X position of legend entry
H2	- initial Y position of legend entry
H3	- length of K$ (individual legend entry)
H4	- length of L$ to the position of K$
H6	- legend choice (1=no legend, 2=new legend, 3=old legend)
H7	- counter for number of legend entries
H$	- flag for pointer function, in the legend and title routine (0=writing only, 1=triangle, 2=square, 3=diamond, 4=+, 5=X, 6=*, 7=dot, C=correct last, E=end)
I, J, K	- temporary variables, usually in do-loops
K$	- string input for legend entry
L	- used in drawing data points
L$	- storage for all K$ from legend routine (dimensioned to 700)

M   - 1-dimensional array used to print data on the printer

M1   - dimension of plotting symbol in the X direction (width)

M2   - dimension of plotting symbol in the Y direction (height)

M3   - symbol size multiplier

M4   - symbol number selector

M5   - selection number in plotting menu (1=symbol size, 2=output device, 3=symbol type, 4=dashed line, 5=end selection)

M6   - dimension of plotting symbol in the Z direction

M7   - used in drawing X,Z points

M$ - symbol selection variable in plot routine

N   - one dimensional array used for the Y component data, inthe dashed line routine

N1, N2 - used in the least squares calculation

N4   - flag indicator for type of X axis in X,Z plot (1=Cartesian X, 2= log X)

N5   - dash pattern selection (for plotter only) (1=_ _ _ _, 2=_._._., 3=....)

N8   - dashed line selection (1=no dashed line, 2=dashed line in X,Y plot, 3=dashed line in X,Z plot)

O1   - output selection variable in plot routine

P   - used in the least squares calculation

P0   - used in numbering the axes

P1   - type of plot required for X,Y plots (1=Cartesian, 2=semilog on X, 3=semilog on Y, 4=log-log)

P2   - selection for axis plot (P2=1) or data only (P2=2)

P3   - first set of data to be plotted (X, Y plot)

P4   - last set of data to be plotted (X, Y plot)

P5   - exponential multiplier in title of X axis of Cartesian plot (P5=0 for all other types)

P6   - temporary variable for numbering Cartesian axes

P7	- exponential multiplier in the title of Y axis of Cartesian plot (P7=0 for all other types)
P9	- indicator for repeat plot 1 = initial plot 2 = repeat plot
P8	- flag for Z axis different type than Y axis (0=Z same as Y, 1=Z different from Y)
P$	- used with P5, P7
Q	- 2-dimensional temporary array used when adding together two sets of data
Q1	- number of first data file when adding two data sets
Q2	- number of second data file when adding two data sets
Q3	- first set of data to be plotted (X, Z plot)
Q4	- last set of data to be plotted (X, Z plot)
Q9	- input/output selection device used for printing, plotting, storing on data tape (1=plotter, 32=screen, 33=tape drive, 41=printer)
Q$	- plot output device (1=plotter, 2=screen)
R	- one dimensional array used for the X component data, in the dashed line routine
R1, R$	- used for changing data points, indicates the raw number
R2	- value of R^2 in least squares calculation
R3	- used when changing data sets
S	- BASIC variable used in formating output
S1	- number of data sets
S2	- S2=70 This is used to dimension the data array, A.
S4	- column number to be sorted in the sorting routine
S5, S6	- used when adding sets of data. Data is added after S5.
S$	- data identification string
T1	- used in sorting routine
T2	- number of sets of data in second data file, when adding two

data files

T7,T8,T9	- used in making axis tic marks
V	- used to define FNX, FNY as Cartesian or logarithmic
V1	- number of columns in data set
V2	- V2=6 This is used to dimension the array, A.
V8	- number of columns in second data file, when adding two data files
W	- 1-dimensional array used for Z data in X, Z plot
W1, W2	- min and max boundaries for Z axis
W3	- range of Z axis (W2-W1) for Cartesian axis, or number of cycles for a log Z axis
W5	- status indicator for X, Z plot, used to determine when points are to be drawn or least squares calculations to be done (0=before X,Z plot; 1=printed X,Z least squares coefficents, 4=plotted X,Z points)
W7	- column number for Z data points
W9	- indicator for Z axis in plot (1=Z axis, 0= no Z axis)
W$	- the Z axis title
X	- 1-dimensional array containing X data for X, Y or X, Z plots
X1, X2	- min and max boundaries for X axis
X3	- range for X axis (X2 - X1) for Cartesian axis, or number of cycles for a log X axis
X6	- used when moving cursor to draw points
X7	- the X-column number
X8	- maximum value within data set (1E300)
X9	- minimum value within data set (-1E300)
X$	- the X axis title
Y	- 1-dimensional array containing Y data for X, Y plot
Y1, Y2	- min and max boundaries for Y axis

Y3	- range of Y axis (Y2 - Y1) for Cartesian axis, or number of cycles for log Y axis
Y6	- used in least squares calculation
Y7	- the Y column number
Y$	- the Y axis title
Z	- temporary variable
Z8, Z9	- used in making axis tic marks
Z$	- temporary variable used for input of answers to questions asked by program (usually Y or N responses)

<u>SIZE OF DIMENSIONED VARIABLES</u>   <u>Appendix III</u>

A(70,6)
A$(10)
B(V1)
B$(25)
C(A2)
C$(5)
D(V1)
D$(5)
E(S1)
E$(20)
F$(12)
G$(12)
H(30,5)
H$(2)
K$(72)
L$(700)
M(V1)
M$(10)
N(S1)
Q(100,V1)
Q$(10)
S$(72)
W(S1)
W$(55)
X(S1)
X$(55)
Y(S1)
Y$(55)
Z$(5)

```
1 REM *** PLOT - A ROUTINE FOR PLOTTING IN CARTESIAN, SEMILOG
2 REM *** AND LOG-LOG COORDINATES.      M. GAUTHIER, FEB 22,1983
3 REM *** REVISED MAY/85    MDG MAYER.    VERSION 5.1
4 REM *** DATA ENTRY***
5 GO TO 100
8 REM *** DATA LIST***
9 GO TO 1040
12 REM *** ADD SETS OF DATA***
13 GO TO 1360
16 REM *** ADD COLUMNS OF DATA***
17 GO TO 1760
20 REM *** CHANGE DATA***
21 GO TO 2030
24 REM *** DELETE DATA SETS***
25 GO TO 2430
28 REM *** DELETE DATA COLUMNS***
29 GO TO 3170
32 REM *** STORE DATA ON MAGTAPE***
33 GO TO 3450
36 REM *** PLOT AXES AND DATA***
37 GO TO 3650
40 REM *** PLOT DATA ONLY***
41 P2=2
42 PAGE
43 GO TO 4360
44 REM *** DATA SORT ROUTINE***
45 GO TO 9800
48 REM *** COLUMN GENERATED FROM EXISTING DATA***
49 GO TO 10100
52 REM *** CONTINUATION OF COLUMN GENERATION***
53 GO TO 10250
56 REM *** CALCULATE Y FROM X,AFTER L.S.***
57 GO TO 10840
60 REM  *** CALCULATE X FROM Y AFTER L.S.***
61 GO TO 11290
64 REM *** ADDING TWO FILES OF DATA (SAME NUMBER OF COLUMNS)***
65 GO TO 11750
68 REM *** LEGEND AND TITLE***
69 H6=2
70 GO TO 5550
72 REM *** CONTINUATION OF PLOT AFTER DASHED LINE ROUTINE***
73 GO TO 6740
76 REM *** REPEAT PLOT***
77 GO TO 12470
90 REM *** INITIALIZATION OF PARAMETERS***
100 INIT
102 SET KEY
104 CHARSIZE 3
106 X9=-1.0E+300
108 X8=1.0E+300
110 M4=1
```

```
112 DELETE A$,B$,C$,D$,E$,F$,G$,H$,K$
114 DELETE M$,P$,Q$,S$,W$,X$,Y$,Z$
116 DIM A$(10),M$(10),Q$(10)
118 DIM E$(20)
120 DIM B$(25)
122 DIM C$(5),D$(5),P$(5),Z$(5)
124 DIM H$(2)
126 DIM F$(12),G$(12)
128 DIM K$(72),S$(72)
130 DIM W$(55),X$(55),Y$(55)
160 Q$="SCREEN"
170 Q9=32
180 M$="TRIANGLE"
190 A$="SQUARE"
200 E$="SET TO OFF"
210 N8=1
220 A4=2
230 A9=0
240 DELETE H
250 DIM H(30,5)
260 H=0
270 H6=1
290 X7=0
300 DELETE L$
310 DIM L$(700)
320 P7=0
330 P5=0
340 P9=1
350 P1=0
360 W5=0
370 P8=0
380 REM ***DATA ENTRY***
385 PRINT "LIPLOT Program"
397 PRINT "JJ NOTE: A MAXIMUM OF 70 DATA SETS AND 6 COLUMNS ARE ALLOWED"
390 PRINT "JJDATA ENTRY FROM TAPE(1) OR KEYBOARD(2)?"
400 INPUT Z
410 GO TO Z OF 420,780
420 PAGE
430 PRINT "IDATA INPUT FROM TAPE"
440 PRINT
450 PRINT "INSERT DATA TAPE NOW GGG"
460 PRINT
470 PRINT "INPUT FILE NUMBER:"
480 INPUT F3
490 FIND F3
500 ON EOF (0) THEN 660
502 READ @33:S1
504 READ @33:V1
506 J1=0
507 J2=6
510 IF S1<=70 AND V1<=6 THEN 530
520 GOSUB 1008
530 V2=6
```

```
            540 S2=70
            550 DELETE A
            560 DIM A(S2,V2)
            570 A=0
            580 FOR I=1 TO S1
            590   FOR J=1 TO V1
            600     READ @33:A(I,J)
            610   NEXT J
            612   IF J2<=6 THEN 620
            614   FOR J=1 TO J2-V1
            616     READ @33:K
            618   NEXT J
+++1+++     620 NEXT I
            622 IF J1=0 THEN 630
            624 FOR I=1 TO J1*J2
            626   READ @33:J
            628 NEXT I
+++1+++     630 READ @33:S$
            640 PRINT S$
            650 GO TO 680
------------------------------------------------------------------
---1---     660 PRINT "INPUT DATA IDENTIFICATION (<72 CHARACTERS)"
            670 INPUT S$
+++1+++     680 FOR I=1 TO S1
            690   PRINT I;"      ";
            700   FOR J=1 TO V1
            710     PRINT A(I,J);"   ";
            720   NEXT J
            730   PRINT
            740 NEXT I
            750 PRINT
            760 END
            770 REM *** DATA INPUT FROM KEYBOARD***
+++1+++     780 PRINT "IDATA INPUT FROM KEYBOARD"
            790 PRINT "JINPUT DATA IDENTIFICATION (<72 CHARACTERS)"
            800 INPUT S$
            810 PRINT "NUMBER OF VARIABLES?"
            820 INPUT V1
            830 PRINT
            840 PRINT "NUMBER OF SETS?"
            850 INPUT S1
            854 IF S1<=70 AND V1<=6 THEN 860
            855 GOSUB 1008
+++1+++     860 S2=70
            870 V2=6
            880 DELETE A
            890 DIM A(S2,V2)
            900 A=0
            910 PRINT "INPUT DATA SETS"
            920 DELETE D
            930 DIM D(V1)
            940 D=0
```

```
         950 FOR I=1 TO S1
         960    PRINT "J";I;"      ";
         970    INPUT D
         980    FOR J=1 TO V1
         990       A(I,J)=D(J)
        1000    NEXT J
        1002 NEXT I
        1004 PRINT "END OF DATA INPUT GGGG"
        1006 END
```

```
---2---  1008 REM DATA FILE LARGER THAN DATA ARRAY
         1010 PRINT "JGGGGNOTE: DATA FILE IS LARGER THAN ALLOWED!"
         1012 PRINT "           ONLY 70 DATA SETS AND 6 COLUMNS"
         1014 PRINT "           WILL BE READ IN"
         1016 IF S1<=70 THEN 1019
         1017 J1=S1-70
         1018 S1=70
+++1+++  1019 J2=V1
         1020 IF V1<=6 THEN 1024
         1022 V1=6
+++1+++  1024 RETURN
+++1+++  1040 REM *** LIST DATA***
         1050 PRINT "LIDATA LIST"
         1060 PRINT "JJ";S$;"JJ"
         1070 PRINT "LIST ON SCREEN(1), OR PRINTER(2)?"
         1080 INPUT Z
+++3+++  1090 GO TO Z OF 1100,1120
+++8+++  1100 Q9=32
         1110 GO TO 1150
+++1+++  1120 Q9=41
         1130 GO TO 10320
         1140 PRINT @Q9:"L"
+++4+++  1150 FOR I=1 TO S1
         1160    PRINT @Q9: USING 1170:I
         1170    IMAGE  5T,FD,9T,S
         1180    FOR J=1 TO V1
         1185       IF A(I,J)=0 THEN 1210
         1190       IF ABS(A(I,J))=>100000 THEN 1240
         1200       IF ABS(A(I,J))<=1.0E-3 THEN 1240
+++1+++  1210       PRINT @Q9: USING 1220:A(I,J)
         1220       IMAGE   -5D.3D,1X,S
         1230       GO TO 1300
+++2+++  1240       IF ABS(A(I,J))<1.0E-9 THEN 1290
         1250       PRINT @Q9: USING 1270:A(I,J)
         1260       IF ABS(A(I,J))<1.0E-9 THEN 1290
         1270       IMAGE 3E,1X,S
         1280       GO TO 1300
+++2+++  1290       PRINT @Q9:"     -     ";
+++2+++  1300    NEXT J
         1310    PRINT @Q9:
         1320 NEXT I
         1330 PRINT @Q9:
         1340 Q9=32
```

```
            1350 END
++++1+++    1360 REM *** ADD SETS OF DATA ***
            1370 PRINT "LIADDING SETS OF DATA"
            1380 PRINT "J";S$;"JJ"
            1390 IF S2>S1 THEN 1420
            1400 PRINT "ARRAY IS FULL, NO MORE SETS CAN BE ADDED"
            1410 GO TO 1750
++++2+++    1420 PRINT "ONLY ";S2-S1;" ADDITIONAL SETS OF DATA ARE ALLOWED"
            1430 PRINT "JNUMBER OF SETS TO BE ADDED=";
            1440 INPUT A1
            1450 IF A1<=S2-S1 THEN 1480
            1460 PRINT "GGGGGGGJJ"
            1470 GO TO 1420
++++2+++    1480 PRINT "JINPUT DATA AFTER SET NUMBER=";
            1490 INPUT S5
            1500 IF S5<=S1 THEN 1530
            1510 PRINT "JSET ";S5;" IS OUT OF RANGE (HIGHEST SET # IS ";S1;")GGGGG"
            1520 GO TO 1480
++++1+++    1530 S6=S5+A1+1
            1540 IF S5=S1 THEN 1600
            1550 FOR I=S1+A1 TO S6 STEP -1
            1560    FOR J=1 TO V1
            1570       A(I,J)=A(I-A1,J)
            1580    NEXT J
            1590 NEXT I
++++1+++    1600 S1=A1+S1
            1610 DELETE B
            1620 DIM B(V1)
            1630 B=0
            1640 PRINT "JINPUT ADDITIONAL SETS, EACH WITH ";V1;" VARIABLES"
            1650 FOR I=1 TO A1
            1660    PRINT "JSET#";I+S5;"     ";
            1670    INPUT B
            1680    FOR J=1 TO V1
            1690       A(S5+I,J)=B(J)
            1700    NEXT J
            1710 NEXT I
            1720 PRINT "JEND OF DATA ENTRY GGGGGJ"
            1730 Z=1
            1740 GO TO 1090
++++1+++    1750 END
++++1+++    1760 REM ***ADD COLUMNS OF DATA ***
            1770 PRINT "LIADD COLUMNS OF DATA"
            1780 PRINT "JJ";S$;"JJ"
            1790 IF V1<V2 THEN 1820
            1800 PRINT "ALL THE COLUMNS ARE FULL"
            1810 GO TO 2020
++++2+++    1820 PRINT " ONLY ";V2-V1;" ADDITIONAL COLUMNS ARE ALLOWED"
            1830 PRINT "J NUMBER OF COLUMNS TO BE ADDED=";
            1840 INPUT A2
```

```
          1850 IF A2<=V2-V1 THEN 1880
          1860 PRINT 'GGGGJ'
          1870 GO TO 1820
+++1+++   1880 DELETE C
          1890 DIM C(A2)
          1900 C=0
          1910 PRINT 'JINPUT ADDITIONAL COLUMNS FOR ';S1;' SETS'
          1920 FOR I=1 TO S1
          1930   PRINT 'J';I;'     ';
          1940   INPUT C
          1950   FOR J=1 TO A2
          1960     A(I,V1+J)=C(J)
          1970   NEXT J
          1980 NEXT I
          1990 PRINT 'JEND OF DATA INPUT GGGGGJ'
          2000 V1=V1+A2
          2010 GO TO 1150
+++1+++   2020 END
+++1+++   2030 REM *** CHANGE DATA***
          2040 PRINT 'L';S$
          2050 PRINT '   ICHANGING DATA          '
          2060 PRINT 'JJCHANGE A SINGLE POINT (1) OR A DATA SET (2)?';
          2070 INPUT K
          2080 PRINT 'JTO STOP, PRESS CARRIAGE RETURN TWICE'
+++4+++   2090 PRINT 'JROW OF DATA TO BE CHANGED=';
          2100 INPUT R$
          2110 IF R$='' THEN 2400
          2120 R1=VAL(R$)
          2130 IF K=2 THEN 2250
          2140 PRINT 'COLUMN OF DATA POINT TO BE CHANGED=';
          2150 INPUT C$
          2160 IF C$='' THEN 2400
          2170 C1=VAL(C$)
          2180 IF R1=>1 OR R1<=S1 THEN 2220
          2190 IF C1=>1 OR C1<=V1 THEN 2220
          2200 PRINT 'JDATA POINT IS OUT OF RANGE'
          2210 GO TO 2090
+++2+++   2220 PRI 'JCURRENT VALUE OF (';R1;',';C1;')=';A(R1,C1);',  CHANGE TO ';
          2230 INPUT A(R1,C1)
          2240 GO TO 2090
+++1+++   2250 IF R1=>1 OR R1<=S1 THEN 2280
          2260 PRINT 'JDATA POINT IS OUT OF RANGEGGGGG'
          2270 GO TO 2090
+++1+++   2280 PRINT 'JCURRENT DATA SET ';R1;' IS:'
          2290 FOR I=1 TO V1
          2300   PRINT A(R1,I);
          2310 NEXT I
          2320 PRINT
          2330 PRINT 'JINPUT VALUES FOR ALL ';V1;' COLUMNS:J'
          2340 FOR I=1 TO V1
```

```
          2350    PRINT "COLUMN #";I;" ";
          2360    INPUT R3
          2370    A(R1,I)=R3
          2380 NEXT I
          2390 GO TO 2090
+++2+++   2400 PRINT
          2410 GO TO 1150
          2420 END
+++1+++   2430 REM *** DELETING DATA SETS***
          2440 PRINT "LIDELETING DATA SETS"
          2450 PRINT "JJ";S$;"JJ"
          2460 DELETE E
          2470 DIM E(S1)
          2480 E=0
          2490 E1=0
          2500 IF S1>0 THEN 2550
          2510 PRINT "ARRAY IS EMPTY"
          2520 END
+++1+++   2550 PRINT "JA CARRIAGE RETURN WITH NO SET NUMBER STOPS INPUT  "
          2560 PRINT "JJIF A WRONG NUMBER IS INPUT, USE BREAK KEY.  THEN all"
          2570 PRINT "                    DELETIONS ENTERED WILL BE CANCELLED"
          2572 PRINT "JDELETING A SINGLE SET (1) OR A BLOCK OF DATA (2)?";
          2574 INPUT K
          2580 IF K=2 THEN 2740
+++2+++   2590 PRINT "JNUMBER OF SET TO BE DELETED=";
          2600 INPUT D$
          2610 IF D$="" THEN 2960
          2620 D1=VAL(D$)
          2630 IF D1=>1 AND D1<=S1 THEN 2660
          2640 PRINT "JSET NUMBER IS OUT OF RANGEGGGGG"
          2650 GO TO 2590
+++1+++   2660 PRINT "SET DELETED =";
          2670 FOR J=1 TO V1
          2680    PRINT A(D1,J);
          2690 NEXT J
          2700 PRINT
          2710 E1=E1+1
          2720 E(E1)=D1
          2730 GO TO 2590
+++2+++   2740 PRINT "JJDELETION OF A BLOCK OF DATA"
+++2+++   2750 PRINT "JINPUT THE FIRST SET OF THE BLOCK:";
          2760 INPUT D$
          2770 IF D$="" THEN 2960
          2780 D3=VAL(D$)
          2790 IF D3<1 OR D3>S1 THEN 2850
          2800 PRINT " INPUT THE LAST SET OF THE BLOCK:";
          2810 INPUT D4
          2820 IF D4<1 OR D4>S1 THEN 2850
          2830 IF D4<D3 THEN 2870
          2840 GO TO 2900
```

```
+++2+++  2850 PRINT "JGGGGBLOCK IS OUT OF RANGE"
         2860 GO TO 2750
+++1+++  2870 PRINT "JGGGG LAST SET # MUST BE HIGHER THAN FIRST SET #"
         2880 GO TO 2750
+++1+++  2900 FOR I=D3 TO D4
         2910    E1=E1+1
         2920    E(E1)=I
         2930 NEXT I
         2940 PRINT "SET NUMBERS ";D3;" TO ";D4;" DELETED"
         2950 GO TO 2740
+++2+++  2960 REM *** SORTING THE SETS TO BE DELETED, THEN RENUMBERING ARRAY***
+++1+++  2970 F4=0
         2980 FOR I=1 TO E1
         2990    IF E(I)=<E(I+1) THEN 3040
         3000    F4=1
         3010    T1=E(I)
         3020    E(I)=E(I+1)
         3030    E(I+1)=T1
+++1+++  3040 NEXT I
         3050 IF F4=1 THEN 2970
         3060 FOR I=1 TO E1
         3070    FOR J=E(I)+1 TO S1
         3080      FOR K=1 TO V1
         3090        A(J-1,K)=A(J,K)
         3100      NEXT K
         3110    NEXT J
         3120    S1=S1-1
         3130 NEXT I
         3140 PRINT
         3150 PRINT "LIST OF REMAINING DATA:"
         3160 GO TO 1100
+++1+++  3170 REM *** DELETE DATA COLUMNS***
         3180 PRINT "LIDELETING DATA COLUMNS"
         3190 PRINT "JJ";S$;"JJ"
+++1+++  3200 IF V1>0 THEN 3230
         3210 PRINT "ARRAY IS EMPTY"
         3220 GO TO 3430
+++1+++  3230 PRINT "JNUMBER OF COLUMN TO BE DELETED=";
         3240 INPUT D$
         3250 IF D$="" THEN 3440
         3260 D2=VAL(D$)
         3270 IF D2=>1 AND D2=<V1 THEN 3300
         3280 PRINT "JGGGGCOLUMN NUMBER IS OUT OF RANGE"
         3290 GO TO 3200
+++1+++  3300 PRINT "JCOLUMN DELETED="
         3310 FOR I=1 TO S1
         3320    PRINT "I";A(I,D2)
         3330 NEXT I
         3340 IF D2=V1 THEN 3400
         3350 FOR J=D2+1 TO V1
```

```
            3360    FOR K=1 TO S1
            3370      A(K,J-1)=A(K,J)
            3380    NEXT K
            3390 NEXT J
+++1+++     3400 V1=V1-1
            3410 Z=1
            3420 PRINT "JREMAINING DATA :J"
+++1+++     3430 GO TO 1090
+++1+++     3440 END
+++1+++     3450 REM *** STORE DATA ON MAG TAPE ***
            3460 PRINT "L STORING DATA ON TAPE"
            3470 PRINT "JJ";S$;"JJ"
            3480 J=(1+S1*V1)*10
            3490 PRINT "JFILE MUST HAVE A MINIMUM OF ";J;" BYTES FOR THIS DATA"
            3500 PRINT "JJINSERT DATA TAPE NOW GGG"
            3510 PRINT
            3520 PRINT "NUMBER OF FILE FOR STORAGE=";
            3530 INPUT Z
            3540 FIND Z
            3550 WRITE @33:S1,V1
            3560 FOR I=1 TO S1
            3570    FOR J=1 TO V1
            3580      WRITE @33:A(I,J)
            3590    NEXT J
            3600 NEXT I
            3610 WRITE @33:S$
            3620 CLOSE
            3630 PRINT "OPERATION COMPLETE; REMOVE DATA TAPE, INSERT PROGRAM TAPE"
            3640 END
+++2+++     3650 REM *** PLOTTING AXES AND DATA ***
            3660 PRINT "LIPLOTTING ROUTINE"
            3670 PRINT "JJ";S$;"JJ"
            3680 P9=1
            3690 PRINT "JDO YOU REQUIRE 2 SEPARATE Y AXES? (Y OR N):";
            3700 INPUT Z$
            3710 IF Z$="N" THEN 3750
            3720 W9=1
            3730 PRINT "THE SECOND Y AXIS WILL BE CALLED THE Z AXIS"
            3740 GO TO 3760
+++1+++     3750 W9=0
+++2+++     3760 PRINT "JJENTER THE X COLUMN NUMBER"
            3770 INPUT X7
            3780 IF X7<1 OR X7>V1 THEN 3760
+++1+++     3790 PRINT "ENTER THE Y COLUMN NUMBER"
            3800 INPUT Y7
            3810 IF Y7<1 OR Y7>V1 THEN 3790
            3820 IF W9=0 THEN 3860
+++1+++     3830 PRINT "ENTER THE Z COLUMN NUMBER"
            3840 INPUT W7
            3850 IF W7<1 OR W7>V1 THEN 3830
```

```
+++1+++   3860 PRINT "I PLOT TYPE SELECTION"
          3870 PRINT "JJ1. CARTESIAN COORDINATES"
          3880 PRINT "J 2. SEMILOG (LOG ALONG X)"
          3890 PRINT "J 3. SEMILOG (LOG ALONG Y)"
          3900 PRINT "J 4. LOG-LOG"
          3910 PRINT "JJINDICATE THE TYPE OF X,Y PLOT NEEDED:";
          3920 INPUT P1
          3930 IF W9=0 THEN 4060
          3940 IF P1>2 THEN 3980
          3950 B$="CARTESIAN COORDINATES"
          3960 E4=0
          3970 GO TO 4000
+++1+++   3980 B$="LOG COORDINATES"
          3990 E4=2
+++1+++   4000 PRINT "J";B$;" FOR Z AXIS (SAME AS Y AXIS)? Y OR N :";
          4010 INPUT Z$
          4020 IF Z$="Y" THEN 4050
          4030 P8=1
          4040 GO TO 4060
+++1+++   4050 P8=0
+++2+++   4060 DELETE X
          4070 DELETE Y
          4080 DIM X(S1)
          4090 DIM Y(S1)
          4100 X=0
          4110 Y=0
          4120 IF W9=0 THEN 4160
          4130 DELETE W
          4140 DIM W(S1)
          4150 W=0
+++1+++   4160 GOSUB P1 OF 7510,7780,8190,8740
          4170 IF W9=0 THEN 4190
          4180 IF P8=1 THEN 14130
+++3+++   4190 PRINT "L DRAW AXES AND DATA(1) OR DATA ONLY(2)?";
          4200 INPUT P2
          4210 GO TO 4230
          4220 P2=1
+++1+++   4230 IF P2=2 THEN 4305
          4240 PRINT "INPUT TITLE FOR X AXIS"
          4250 INPUT X$
          4260 PRINT "INPUT TITLE FOR Y AXIS (ALONG LEFT SIDE)"
          4270 INPUT Y$
          4280 IF W9=0 THEN 4360
          4290 PRINT "INPUT TITLE FOR Z AXIS (ALONG RIGHT SIDE)"
          4300 INPUT W$
+++1+++   4305 IF W9=0 THEN 4360
+++1+++   4310 PRINT "FOR X,Y PLOT ENTER FIRST AND LAST SETS TO BE PLOTTED:";
          4320 INPUT P3,P4
          4330 PRINT "JFOR X,Z PLOT ENTER FIRST AND LAST SETS TO BE PLOTTED:";
          4340 INPUT Q3,Q4
```

```
           4350 GO TO 4390
+++3+++    4360 IF W9=1 THEN 4310
           4370 PRINT 'ENTER NUMBER OF FIRST AND LAST SETS TO BE PLOTTED:';
           4380 INPUT P3,P4
+++1+++    4390 REM LEGEND AND TITLE
           4400 PRINT 'LILEGENDS AND TITLES'
           4410 PRINT 'LEGEND CHOICES:'
           4420 PRINT '          1. NO LEGEND'
           4430 PRINT '          2. NEW LEGEND'
           4440 PRINT '          3. OLD LEGEND'
           4450 INPUT H6
+++1+++    4460 REM*** GOTO SELECTION MENU FOR SYMBOL TYPE ETC.***
           4470 GOSUB 6720
+++1+++    4480 REM *** AXES PLOT***
           4490 PRINT 'L';S$
           4500 VIEWPORT 20,85,33,98
           4510 WINDOW X1,X2,Y1,Y2
           4520 IF Q9=32 THEN 4550
           4530 VIEWPORT 17,82,50,115
           4540 WINDOW X1,X2,Y1,Y2
+++1+++    4550 W5=0
           4560 IF P2=2 THEN 4800
           4570 MOVE @Q9:X1,Y1
           4580 T9=Y3/100
           4590 T8=0
           4600 T7=X3
           4610 GOSUB P1 OF 6320,5580,6320,5580
           4620 MOVE @Q9:X1,Y2
           4630 T9=-T9
           4640 GOSUB P1 OF 6320,5580,6320,5580
           4650 MOVE @Q9:X1,Y1
           4660 T7=Y3
           4670 T9=X3/100
           4680 GOSUB P1 OF 6410,6410,5700,5700
           4690 IF W9=1 THEN 12590
           4700 T9=-T9
           4710 MOVE @Q9:X2,Y1
           4720 GOSUB P1 OF 6410,6410,5700,5700
+++2+++    4730 MOVE @Q9:X1,Y1
           4740 P0=X1
           4750 GOSUB P1 OF 6500,5820,6500,5820
           4760 T9=X1
           4770 P0=Y1
           4780 GOSUB P1 OF 6610,6610,5890,5890
           4790 GOSUB 5990
+++1+++    4800 REM *** DRAWING POINTS FOR X,Y PLOT ***
           4810 IF P3=0 OR P4=0 THEN 5520
           4820 FOR I=P3 TO P4
           4830    X6=X(I)
           4840    IF X(I)>X8 OR X(I)<X9 THEN 4900
```

```
             4850    L=Y(I)
             4860    G1=0
             4870    MOVE @Q9:X6,L
             4880    REM *** DRAW POINT USING CHOSEN SYMBOL***
             4890    GOSUB 9360
+++1+++      4900 NEXT I
             4910 REM *** CALCULATION OF LEAST SQUARES***
             4920 IF P3=0 OR P4=0 THEN 5470
             4930 P=0
             4940 G=0
             4950 F=0
             4960 F1=0
             4970 N1=0
             4980 FOR I=P3 TO P4
             4990    X6=X(I)
             5000    IF X(I)<X9 OR X(I)>X8 THEN 5090
             5010    Y6=Y(I)
             5020    P=P+X6*Y6
             5030    G=G+Y6
             5040    F=F+X6
             5050    F1=F1+X6^2
             5060    N1=N1+1
             5070    G1=G1+Y6^2
             5080    HOME
+++1+++      5090 NEXT I
+++1+++      5100 IF N1>1 THEN 5130
             5110 PRINT 'NO DATA IN CURRENT SELECTION'
             5120 END
+++1+++      5130 IF N1*F1-F^2<>0 THEN 5170
             5140 HOME @Q9:
             5150 PRINT USING '32''J''IX''REGRESSION LINE IS VERTICAL''';
             5160 END
+++1+++      5170 B1=(N1*P-G*F)/(N1*F1-F^2)
             5180 A3=(G-B1*F)/N1
             5190 D6=X1
             5200 D7=X2
             5210 N2=1/N1
             5220 R2=(A3*G+B1*P-N2*G^2)/(G1-N2*G^2)
             5230 REM ***DRAW G(Y)=A3+B1*F(X)
             5240 PRINT 'J '
             5250 PRINT 'JPLOT THE BEST STRAIGHT LINE AND PRINT R^2 (1),'
             5260 PRINT '   PRINT R^2 ONLY (2) OR NEITHER (3)?';
             5270 INPUT Z
             5280 GO TO Z OF 5290,5310,5470
+++1+++      5290 MOVE @Q9:D6,A3+D6*B1
             5300 DRAW @Q9:D7,A3+D7*B1
+++1+++      5310 HOME
             5320 PRINT 'JJJJJ'
             5330 IF W5=4 THEN 13900
             5340 GO TO P1 OF 5350,5380,5410,5440
```

```
+++1+++   5350 PRINT USING 5360:A3,B1
          5360 IMAGE "Y=",+4E,X,+4E,"* X"
          5370 GO TO 5460
+++1+++   5380 PRINT USING 5390:A3,B1
          5390 IMAGE "Y=",+4E,X,+4E,"* LOG X"
          5400 GO TO 5460
+++1+++   5410 PRINT USING 5420:A3,B1
          5420 IMAGE "LOG Y=",+4E,X,+4E,"* X"
          5430 GO TO 5460
+++1+++   5440 PRINT USING 5450:A3,B1
          5450 IMAGE "LOG Y=",+4E,X,+4E,"* LOG X"
+++3+++   5460 PRINT "COEF OF DETERMINATION (R^2) = ";R2
+++2+++   5470 IF W9=0 THEN 5500
          5480 IF W5=0 THEN 13530
          5490 GO TO 14050
+++1+++   5500 B4=B1
          5510 A6=A3
+++2+++   5520 REM **DASHED LINE ROUTINE***
          5530 IF N8=1 THEN 5550
          5540 GOSUB 14820
+++2+++   5550 REM ***PRINTING LEGEND AND TITLE ***
          5560 GOSUB H6 OF 5570,15490,16380

--------------------------------------------------------------------------

---1---   5570 END

--------------------------------------------------------------------------

---4---   5580 REM *** DRAW LOG TICK MARKS AND X AXIS***
          5590 FOR I=1 TO T7
          5600    Z8=0
          5610    FOR J=2 TO 10
          5620       Z9=LGT(J)
          5630       RDRAW @Q9:Z9-Z8,T8
          5640       RDRAW @Q9:T8,T9
          5650       RDRAW @Q9:T8,-T9
          5660       Z8=Z9
          5670    NEXT J
          5680 NEXT I
          5690 RETURN

--------------------------------------------------------------------------

---4---   5700 REM *** LOG TICK MARKS AND Y AXIS***
          5710 FOR I=1 TO T7
          5720    Z8=0
          5730    FOR J=2 TO 10
          5740       Z9=LGT(J)
          5750       RDRAW @Q9:T8,Z9-Z8
          5760       RDRAW @Q9:T9,T8
          5770       RDRAW @Q9:-T9,T8
          5780       Z8=Z9
```

```
         5790    NEXT J
        5800 NEXT I
        5810 RETURN
```

---2---
```
        5820 REM *** NUMBERING THE X AXIS***
        5830 FOR I=1 TO X3+1
        5840    PRINT @Q9:"JJH10K";PO;
        5850    MOVE @Q9:X1+I,Y1
        5860    PO=PO+1
        5870 NEXT I
        5880 RETURN
```

---2---
```
        5890 REM ***NUMBERING THE Y AXIS***
        5900 FOR I=0 TO Y3
        5910    MOVE @Q9:T9,Y1+I
        5920    PRINT @Q9:"HHHHH10K";PO;
        5930    PO=PO+1
        5940 NEXT I
        5950 RETURN
        5960 F4=0
        5970 FOR I=1 TO S1-1
        5980    IF A(I,S4)=>A(I+1,S4) THEN 9970
```

---1---
```
        5990    REM *** PRINTING X TITLE***
        6000    CHARSIZE 3
        6010    MOVE @Q9:X1+X3/2,Y1
        6020    IF P9=0 THEN 6070
        6030    IF P7=0 THEN 6070
        6040    P$=STR(P7)
        6050    X$=X$&" *10K"
        6060    X$=X$&P$
```
+++2+++
```
        6070    FOR J=1 TO LEN(X$)/2
        6080       PRINT @Q9:"H";
        6090    NEXT J
        6100    PRINT @Q9:"JJJJJ";X$
        6110    MOVE @Q9:X1,Y1+Y3/2
        6120    REM *** Y TITLE ***
        6130    IF P1=3 OR P1=4 THEN 6160
```
+++1+++
```
        6160    PRINT @Q9:"HHHHHHH";
        6170    SET DEGREES
        6180    PRINT @Q9,25:90
        6190    IF P9=0 THEN 6240
        6200    IF P5=0 THEN 6240
        6210    P$=STR(P5)
        6220    Y$=Y$&" *10K"
        6230    Y$=Y$&P$
```
+++2+++
```
        6240    FOR J=1 TO LEN(Y$)/2
```

```
            6250      PRINT @Q9:"H";
            6260   NEXT J
            6270   PRINT @Q9:Y$
            6280   PRINT @Q9,25:0
            6290   IF W9=1 THEN 13130
+++1+++     6300   CHARSIZE 2
            6310   RETURN
```

```
---4---     6320   REM ***DRAW CARTESIAN TICK MARKS AND X AXIS***
            6330   Z8=0
            6340   Z9=(X2-X1)/10
            6350   FOR J=1 TO 10
            6360      RDRAW @Q9:Z9,T8
            6370      RDRAW @Q9:T8,T9
            6380      RDRAW @Q9:T8,-T9
            6390   NEXT J
            6400   RETURN
```

```
---4---     6410   REM *** DRAW CARTESIAN TICK MARKS AND Y AXIS***
            6420   Z8=0
            6430   Z9=(Y2-Y1)/10
            6440   FOR J=1 TO 10
            6450      RDRAW @Q9:T8,Z9
            6460      RDRAW @Q9:T9,T8
            6470      RDRAW @Q9:-T9,T8
            6480   NEXT J
            6490   RETURN
```

```
---2---     6500   REM *** NUMBER X AXIS (CARTESIAN)***
            6510   Z9=(X2-X1)/5
            6520   P7=INT(LGT(ABS(X1)+ABS(Z9))+1.0E-8)
            6530   FOR I=1 TO 6
            6540      P6=P0/10^P7
            6550      PRINT @Q9:"JJHHH";
            6560      PRINT @Q9: USING "-2D.2D":P6
            6570      P0=X1+Z9*I
            6580      MOVE @Q9:P0,Y1
            6590   NEXT I
            6600   RETURN
```

```
---2---     6610   REM *** NUMBER Y AXIS (CARTESIAN)***
            6620   Z9=(Y2-Y1)/5
            6630   P5=INT(LGT(ABS(Y1)+ABS(Z9))+1.0E-8)
            6640   FOR I=1 TO 6
            6650      MOVE @Q9:T9,P0
            6660      P6=P0/10^P5
```

```
        6670     PRINT @Q9:"HHHHHHH";
        6680     PRINT @Q9: USING "-2D.2D":P6
        6690     PO=Y1+Z9*I
        6700     NEXT I
        6710     RETURN
```

```
---1---  6720     REM *** SELECTION MENU ROUTINE ***
         6730     M3=1
+++16++  6740     HOME
         6750     PAGE
         6760     IF H6<>2 THEN 6780
         6770     Q9=32
+++1+++  6780     IF Q9=1 THEN 6810
         6790     Q$="SCREEN"
         6800     GO TO 6820
+++1+++  6810     Q$="PLOTTER"
+++1+++  6820     PRINT "I SELECTION MENU"
         6830     PRINT "1. ALTER SYMBOL SIZE (SET TO ";M3;" NOW)"
         6840     PRINT "2. SELECT OUTPUT DEVICE (SET TO ";Q$;" NOW)"
         6850     IF W9=0 THEN 6890
         6860     PRINT "3. SELECT SYMBOL (SET TO ";M$;" FOR X,Y POINTS)"
         6870     PRINT "                          (SET TO ";A$;" FOR X,Z POINTS)"
         6880     GO TO 6900
+++1+++  6890     PRINT "3. SELECT SYMBOL (SET TO ";M$;" NOW)"
+++1+++  6900     PRINT "4. DASHED LINE CURVE (";E$;" NOW)"
         6910     PRINT
         6920     PRINT "5. END SELECTION"
         6930     PRINT
         6940     PRINT "ENTER SELECTION NUMBER:";
         6950     INPUT M5
         6960     IF M5<1 OR M5>5 THEN 6740
         6970     PAGE
         6980     HOME
         6990     GO TO M5 OF 7000,7070,7210,14530,7480
+++1+++  7000     REM ***ALTER SYMBOL SIZE***
         7010     PRINT "ENTER SYMBOL SIZE MULTIPLIER:";
         7020     INPUT M3
         7030     IF M3=0 THEN 6740
         7040     M1=M1*M3
         7050     M2=M2*M3
         7060     GO TO 6740
+++1+++  7070     REM*** OUTPUT DEVICE ***
         7080     PRINT "1.SCREEN"
         7090     PRINT "2.PLOTTER"
         7100     PRINT
         7110     PRINT "ENTER OUTPUT DEVICE SELECTION:";
         7120     INPUT O1
         7130     IF O1<1 OR O1>2 THEN 6740
         7140     IF O1=1 THEN 7180
```

```
            7150    Q9=1
            7160    Q$="PLOTTER"
            7170    GO TO 6740
+++1+++     7180    Q9=32
            7190    Q$="SCREEN"
            7200    GO TO 6740
+++1+++     7210    REM *** SYMBOL SELECTION ***
            7220    PRINT "J1. TRIANGLE"
            7230    PRINT " 2. SQUARE"
            7240    PRINT " 3. DIAMOND"
            7250    PRINT " 4.`+`"
            7260    PRINT " 5.`X`"
            7270    PRINT " 6.`*`"
            7280    PRINT " 7.POINT"
            7290    IF W9=1 THEN 13330
            7300    PRINT "J ENTER SYMBOL NUMBER:";
+++1+++     7310    INPUT M4
            7320    IF M4<1 OR M4>7 THEN 6740
            7330    GO TO M4 OF 7340,7360,7380,7400,7420,7440,7460
+++1+++     7340    M$="TRIANGLE"
            7350    GO TO 6740
+++1+++     7360    M$="SQUARE"
            7370    GO TO 6740
+++1+++     7380    M$="DIAMOND"
            7390    GO TO 6740
+++1+++     7400    M$="`+`"
            7410    GO TO 6740
+++1+++     7420    M$="`X`"
            7430    GO TO 6740
+++1+++     7440    M$="`*`"
            7450    GO TO 6740
+++1+++     7460    M$="POINT"
            7470    GO TO 6740
+++1+++     7480    IF N8>1 THEN 4480
            7490    RETURN
            7500    REM ***END OF SELECTION MENU***

---1---     7510    REM*** CARTESIAN COORDINATES***
            7520    FOR I=1 TO S1
            7530      X(I)=A(I,X7)
            7540      Y(I)=A(I,Y7)
            7550    NEXT I
            7560    IF W9=0 THEN 7610
            7570    IF F8=1 THEN 7610
            7580    FOR I=1 TO S1
            7590      W(I)=A(I,W7)
            7600    NEXT I
+++2+++     7610    PRINT "JINPUT BOUNDARIES FOR X (MIN,MAX):";
            7620    INPUT X1,X2
```

```
           7630    PRINT "JINPUT BOUNDARIES FOR Y (MIN,MAX):";
           7640    INPUT Y1,Y2
           7650    IF W9=0 THEN 7710
           7660    IF P8=1 THEN 7710
           7670    PRINT "JINPUT BOUNDARIES FOR Z (MIN,MAX):";
           7680    INPUT W1,W2
           7690    W3=W2-W1
           7700    DEF FNW(V)=V
+++2+++    7710    M2=(Y2-Y1)/100
           7720    M1=(X2-X1)/100
           7730    X3=X2-X1
           7740    Y3=Y2-Y1
           7750    DEF FNX(V)=V
           7760    DEF FNY(V)=V
           7770    RETURN
-------------------------------------------------------------------------------
---1---    7780    REM *** SEMILOG ON X AXIS***
           7790    I=1
+++1+++    7800    IF I=S1+1 THEN 7870
           7810    IF A(I,X7)=0 THEN 7840
           7820    I=I+1
           7830    GO TO 7800
+++1+++    7840    PRINT "GGGGGERROR: A ZERO VALUE HAS BEEN FOUND IN THE  X DATA"
           7850    PRINT "IT MUST BE REMOVED BEFORE A LOG PLOT CAN BE MADE"
           7860    GO TO 1100
+++1+++    7870    FOR I=1 TO S1
           7880       X(I)=LGT(A(I,X7))
           7890       Y(I)=A(I,Y7)
           7900    NEXT I
           7910    IF W9=0 THEN 7960
           7920    IF P8=1 THEN 7960
           7930    FOR I=1 TO S1
           7940       W(I)=A(I,W7)
           7950    NEXT I
+++3+++    7960    PRINT "JINPUT MINIMUM BOUNDARY FOR X AND NO. OF CYCLES:";
           7970    INPUT X1,X3
           7980    IF X1>0 THEN 8010
           7990    PRINT "GGJIMINIMUM X MUST BE GREATER THAN ZEROJ"
           8000    GO TO 7960
+++1+++    8010    X1=X1+1.0E-3
           8020    PRINT "JINPUT BOUNDARIES FOR Y,(MIN,MAX):";
           8030    INPUT Y1,Y2
           8040    IF W9=0 THEN 8100
           8050    IF P8=1 THEN 8100
           8060    PRINT "JINPUT BOUNDARIES FOR Z,(MIN,MAX):";
           8070    INPUT W1,W2
           8080    W3=W2-W1
           8090    DEF FNW(V)=V
+++2+++    8100    Y3=Y2-Y1
```

```
         8110    X1=INT(LGT(X1))
         8120    X2=X1+X3
         8130    M1=X3/100
         8140    M2=(Y2-Y1)/100
         8150    DEF FNX(V)=LGT(V)
         8160    P7=0
         8170    DEF FNY(V)=V
         8180    RETURN
```

--+----

```
---1---  8190    REM *** SEMILOG ON Y AXIS ***
         8200    I=1
+++1+++  8210    IF I=S1+1 THEN 8280
         8220    IF A(I,Y7)=0 THEN 8250
         8230    I=I+1
         8240    GO TO 8210
+++1+++  8250    PRINT "GGGGGERROR: A ZERO VALUE HAS BEEN FOUND IN THE  Y DATA"
         8260    PRINT "IT MUST BE REMOVED BEFORE A LOG PLOT CAN BE MADE"
         8270    GO TO 1100
+++1+++  8280    FOR I=1 TO S1
         8290       X(I)=A(I,X7)
         8300       Y(I)=LGT(A(I,Y7))
         8310    NEXT I
         8320    IF W9=0 THEN 8450
         8330    IF P8=1 THEN 8450
         8340    I=1
+++1+++  8350    IF I=S1+1 THEN 8420
         8360    IF A(I,W7)=0 THEN 8390
         8370    I=I+1
         8380    GO TO 8350
+++1+++  8390    PRINT "GGGGGERROR: A ZERO VALUE HAS BEEN FOUND IN THE  Z DATA"
         8400    PRINT "IT MUST BE REMOVED BEFORE A LOG PLOT CAN BE MADE"
         8410    GO TO 1100
+++1+++  8420    FOR I=1 TO S1
         8430       W(I)=LGT(A(I,W7))
         8440    NEXT I
+++2+++  8450    PRINT "JINPUT BOUNDARIES FOR X AXIS,(MIN,MAX):";
         8460    INPUT X1,X2
+++1+++  8470    PRINT "JINPUT MINIMUM BOUNDARY FOR Y AND NO. OF CYCLES:";
         8480    INPUT Y1,Y3
         8490    IF Y1>0 THEN 8520
         8500    PRINT "GGIJ MINIMUM Y MUST BE GREATER THAN ZEROJ"
         8510    GO TO 8470
+++1+++  8520    Y1=Y1+1.0E-3
         8530    X3=X2-X1
         8540    Y1=INT(LGT(Y1))
         8550    Y2=Y1+Y3
         8560    M2=Y3/100
         8570    M1=(X2-X1)/100
         8580    DEF FNX(V)=V
```

```
            8590    DEF FNY(V)=LGT(V)
            8600    P5=0
            8610    IF W9=0 THEN 8730
            8620    IF P8=1 THEN 8730
+++1+++     8630    PRINT "JINPUT MINIMUM BOUNDARY FOR Z AND NO. OF CYCLES:";
            8640    INPUT W1,W3
            8650    A9=0
            8660    IF W1>0 THEN 8690
            8670    PRINT "GGIJMINIMUM Z MUST BE GREATER THAN ZEROJ"
            8680    GO TO 8630
+++1+++     8690    W1=W1+1.0E-3
            8700    W1=INT(LGT(W1))
            8710    W2=W1+W3
            8720    DEF FNW(V)=LGT(V)
+++2+++     8730    RETURN
```

```
---1---     8740    REM ***LOG-LOG COORDINATES***
            8750    I=1
+++1+++     8760    IF I=S1+1 THEN 8840
            8770    IF A(I,X7)=0 THEN 8810
            8780    IF A(I,Y7)=0 THEN 8810
            8790    I=I+1
            8800    GO TO 8760
+++2+++     8810    PRINT "GGGGGERROR: A ZERO VALUE HAS BEEN FOUND IN THE DATA"
            8820    PRINT "IT MUST BE REMOVED BEFORE A LOG PLOT CAN BE MADE"
            8830    GO TO 1100
+++1+++     8840    FOR I=1 TO S1
            8850       X(I)=LGT(A(I,X7))
            8860       Y(I)=LGT(A(I,Y7))
            8870    NEXT I
            8880    IF W9=0 THEN 9000
            8885    IF P8=1 THEN 9000
            8890    I=1
+++1+++     8900    IF I=S1+1 THEN 8970
            8910    IF A(I,W7)=0 THEN 8940
            8920    I=I+1
            8930    GO TO 8900
+++1+++     8940    PRINT "GGGGGERROR: A ZERO VALUE HAS BEEN FOUND IN THE  Z DATA"
            8950    PRINT "IT MUST BE REMOVED BEFORE A LOG PLOT CAN BE MADE"
            8960    GO TO 1100
+++1+++     8970    FOR I=1 TO S1
            8980       W(I)=LGT(A(I,W7))
            8990    NEXT I
+++3+++     9000    PRINT "JINPUT MINIMUM BOUNDARY FOR X AND NO. OF CYCLES:";
            9010    INPUT X1,X3
            9020    IF X1>0 THEN 9050
            9030    PRINT "GGIJMINIMUM X MUST BE GREATER THAN ZEROJ"
            9040    GO TO 9000
+++1+++     9050    X1=X1+1.0E-3
```

```
+++1+++   9060    PRINT "JINPUT MINIMUM BOUNDARY FOR Y AND NO. OF CYCLES:";
          9070    INPUT Y1,Y3
          9080    IF Y1>0 THEN 9110
          9090    PRINT "GGIJMINIMUM Y MUST BE GREATER THAN ZEROJ"
          9100    GO TO 9060
+++1+++   9110    Y1=Y1+1.0E-3
          9120    IF W9=0 THEN 9250
          9130    IF P8=1 THEN 9250
+++1+++   9140    PRINT "JINPUT MINIMUM BOUNDARY FOR Z AND NO. OF CYCLES:";
          9150    INPUT W1,W3
          9160    IF W1>0 THEN 9190
          9170    PRINT "GGIJMINIMUM Z MUST BE GREATER THAN ZEROJ"
          9180    GO TO 9140
+++1+++   9190    W1=W1+1.0E-3
          9200    W1=INT(LGT(W1))
          9210    W2=W1+W3
          9220    DEF FNW(V)=LGT(V)
          9230    M6=W3/100
          9240    A9=0
+++2+++   9250    Y1=INT(LGT(Y1))
          9260    X1=INT(LGT(X1))
          9270    X2=X1+X3
          9280    Y2=Y1+Y3
          9290    DEF FNX(V)=LGT(V)
          9300    DEF FNY(V)=LGT(V)
          9310    M1=X3/100
          9320    M2=Y3/100
          9330    P5=0
          9340    P7=0
          9350    RETURN

---2---   9360    REM***SYMBOL PLOTTING ROUTINE***
          9370    REM *** M1=SYMBOL WIDTH, M2=SYMBOL HEIGHT***
          9380    GO TO M4 OF 9390,9450,9520,9590,9650,9710,9760

---3---   9390    REM ***TRIANGLE***
          9400    RMOVE @Q9:0,M2
          9410    RDRAW @Q9:M1,-2*M2
          9420    RDRAW @Q9:-2*M1,0
          9430    RDRAW @Q9:M1,2*M2
          9440    RETURN

---3---   9450    REM*** SQUARE***
          9460    RMOVE @Q9:M1,M2
          9470    RDRAW @Q9:0,-2*M2
          9480    RDRAW @Q9:-2*M1,0
          9490    RDRAW @Q9:0,2*M2
```

```
          9500    RDRAW @Q9:2*M1,0
          9510    RETURN

---------------------------------------------------------------
---3---   9520    REM***DIAMOND***
          9530    RMOVE @Q9:0,M2
          9540    RDRAW @Q9:M1,-M2
          9550    RDRAW @Q9:-M1,-M2 .
          9560    RDRAW @Q9:-M1,M2
          9570    RDRAW @Q9:M1,M2
          9580    RETURN

---------------------------------------------------------------
---4---   9590    REM ***'+'***
          9600    RMOVE @Q9:0,M2
          9610    RDRAW @Q9:0,-2*M2
          9620    RMOVE @Q9:M1,M2
          9630    RDRAW @Q9:-2*M1,0
          9640    RETURN

---------------------------------------------------------------
---3---   9650    REM ***'X'***

---------------------------------------------------------------
---1---   9660    RMOVE @Q9:M1,M2
          9670    RDRAW @Q9:-2*M1,-2*M2
          9680    RMOVE @Q9:2*M1,0
          9690    RDRAW @Q9:-2*M1,2*M2
          9700    RETURN

---------------------------------------------------------------
---3---   9710    REM ***'*'
          9720    GOSUB 9590
          9730    RMOVE M1,0
          9740    GOSUB 9660
          9750    RETURN

---------------------------------------------------------------
---3---   9760    REM *** POINT***
          9770    RDRAW @Q9:0,0
          9780    RETURN
          9790    REM*** END SYMBOL PLOTTING ROUTINE***
+++1+++   9800    REM *** DATA SORT ROUTINE***
          9810    PRINT 'LI SORTING ROUTINE (HIGH VALUES FIRST)'
          9820    PRINT "JJ";S$;"JJ"
          9830    PRINT 'J INPUT THE COLUMN THAT IS TO BE SORTED: ';
          9840    INPUT S4
          9850    IF S4>1 OR S4<V1 THEN 9880
          9860    PRINT 'J COLUMN IS OUT OF RANGE'
          9870    GO TO 10080
```

```
+++2+++   9880    F4=0
          9890    FOR I=1 TO S1-1
          9900      IF A(I,S4)=>A(I+1,S4) THEN 9970
          9910      F4=1
          9920      FOR J=1 TO V1
          9930        T1=A(I,J)
          9940        A(I,J)=A(I+1,J)
          9950        A(I+1,J)=T1
          9960      NEXT J
+++2+++   9970    NEXT I
          9980    IF F4=1 THEN 9880
          9990    PRINT 'JISORTED VALUES'
          10000    PRINT
          10010    FOR I=1 TO S1
          10020      PRINT I;'    ';
          10030      FOR J=1 TO V1
          10040        PRINT USING 1220;A(I,J)
          10050      NEXT J
          10060      PRINT
          10070    NEXT I
+++1+++   10080   END
          10090   REM ***END SORTING ROUTINE***
+++1+++   10100   REM **COLUMN GENERATED FROM EXISTIING DATA***
          10110   PRINT 'LICOLUMN GENERATED FROM EXISTING DATA'
          10120   PRINT 'JJ';S$;'JJ'
          10130   IF V1<V2 THEN 10160
          10140   PRINT 'JJNO MORE COLUMNS ALLOWEDGGGG'
          10150   GO TO 10310
+++1+++   10160   PRINT 'J1. COLUMN TO BE TRANSFORMED IS WRITTEN IN ARRAY FORMAT'
          10170   PRINT '   i.e.A(I,n) WHERE n IS THE COLUMN NUMBER.'
          10180   PRINT '2. THE TRANSFORMATION IS INPUT BY RFCALLING LINE 10260,'
          10190   PRINT '   AND CHANGING THE EQUATION'
          10200   PRINT '3. ONLY THE RIGHT HAND SIDE OF THF EQUATON IS CHANGED'
          10210   PRINT '   i.e. FOR Y=1/X, INPUT  1/A(I,3), IF USING COLUMN 3'
          10220   PRINT '4. RECALL 10260, MAKE ANY CHANGES, PRESS USER KEY #13'
          10230   PRINT 'JJ ONLY ';V2-V1;' MORE COLUMNS ARE ALLOWED!'
          10240   END
+++1+++   10250   FOR I=1 TO S1
          10260     A(I,V1+1)=A(I,5)*10
          10270   NEXT I
          10280   V1=V1+1
          10290   Z=1
          10300   GO TO 1090
+++1+++   10310   END
+++1+++   10320   REM *** LIST ON PRINTER WITH VARIABLE E FORMAT****
          10330   DELETE M
          10340   DIM M(V1)
          10350   M=0
          10360   PRINT 'IS SCIENTIFIC NOTATION FORMAT REQUIRED (Y OR N)?';
          10370   INPUT Z$
```

```
           10380    IF Z$='Y' THEN 10410
           10390    PRINT @Q9:'LJJI';S$;'JJ'
           10400    IF Z$='N' THEN 1150
+++1+++    10410    PRINT 'JINPUT NUMBER OF SIGNIFICANT FIGURES (3 TO 6)'
           10420    FOR I=1 TO V1
+++1+++    10430      PRINT 'JFOR COLUMN ';I;' =';
           10440      INPUT Z
           10450      IF Z<3 OR Z>6 THEN 10430
           10460      M(I)=Z-2
           10470    NEXT I
           10490    PRINT @Q9:'L'
           10500    PRINT @Q9:'JJJJJJJJJJ'
           10510    FOR I=1 TO S1
           10520      PRINT @Q9:'        ';
           10530      FOR J=1 TO V1
           10540        IF A(I,J)<1.0E-9 THEN 10760
           10550        GO TO V1-1 OF 10560,10580,10600,10620,10620
+++1+++    10560        PRINT @Q9: USING '12X,S':
           10570        GO TO 10630
+++1+++    10580        PRINT @Q9: USING '6X,S':
           10590        GO TO 10630
+++1+++    10600        PRINT @Q9: USING '2X,S':
           10610        GO TO 10630
+++2+++    10620        PRINT @Q9: USING '1X,S':
+++3+++    10630        GO TO M(J) OF 10640,10670,10700,10730
+++1+++    10640        PRINT @Q9: USING 10650:A(I,J)
           10650        IMAGE      2E,S
           10660        GO TO 10780
+++1+++    10670        PRINT @Q9: USING 10680:A(I,J)
           10680        IMAGE      3E,S
           10690        GO TO 10780
+++1+++    10700        PRINT @Q9: USING 10710:A(I,J)
           10710        IMAGE      4E,S
           10720        GO TO 10780
+++1+++    10730        PRINT @Q9: USING 10740:A(I,J)
           10740        IMAGE      5E,S
           10750        GO TO 10780
+++1+++    10760        PRINT @Q9: USING 10770:
           10770        IMAGE 5X,'  -    ',S
+++4+++    10780      NEXT J
           10790      PRINT @Q9:
           10800    NEXT I
           10810    PRINT @Q9:
           10820    Q9=32
           10830    END
+++1+++    10840    REM *** CALCULATION OF Y FROM X AFTER L.S.***
           10850    PRINT 'L I CALCULATION OF Y FROM X'
           10860    PRINT 'J THIS CAN ONLY BE USED AFTER A PLOT HAS BEEN MADE'
           10870    PRINT ' STOP CALCULATIONS WITH A CARRIAGE RETURN'
           10880    PRINT 'J THE CALCULATIONS ASSUME A STRAIGHT LINE, AND'
```

```
        10890    PRINT "  USE THE LEAST SQUARES PARAMETERS."
        10895    Z=1
        10900    IF W9=0 THEN 10930
        10910    PRINT "JJCALCULATE Y (1) OR Z (2) FROM X?";
        10920    INPUT Z
+++1+++ 10930    PRINT "JLIST ON SCREEN (1) OR PRINTER (2)?";
        10940    INPUT I
        10950    IF I=2 THEN 10980
        10960    Q9=32
        10970    GO TO 10990
+++1+++ 10980    Q9=41
        10985    PRINT @Q9:"LIJJ";S$;"JJJ"
+++1+++ 10990    IF Z=1 THEN 11040
        11000    A3=A5
        11010    B1=B3
        11020    Z$="Z EST"
        11030    GO TO 11070
+++1+++ 11040    A3=A6
        11050    B1=B4
        11060    Z$="Y EST"
+++2+++ 11070    PRINT "JINPUT X:";
        11080    INPUT F$
        11090    IF F$="" THEN 11270
        11100    F2=VAL(F$)
        11110    IF Z=1 THEN 11140
        11120    IF P8=0 THEN 11140
        11130    GO TO E4+N4 OF 11150,11170,11190,11220
+++2+++ 11140    GO TO P1 OF 11150,11170,11190,11220
+++2+++ 11150    G2=A3+B1*F2
        11160    GO TO 11240
+++2+++ 11170    G2=A3+B1*LGT(F2)
        11180    GO TO 11240
+++2+++ 11190    G2=A3+B1*F2
        11200    G2=10^G2
        11210    GO TO 11240
+++2+++ 11220    G2=A3+B1*LGT(F2)
        11230    G2=10^G2
+++3+++ 11240    PRINT @Q9:"I X=";F2;"II";Z$;"=";G2
        11250    PRINT
        11260    GO TO 11070
+++1+++ 11270    Q9=32
        11280    END
+++1+++ 11290    REM *** CALCULATE X FROM Y AFTER L.S.***
        11300    PRINT "L I CALCULATION OF X FROM Y"
        11310    PRINT "J THIS CAN BE USED ONLY AFTER A PLOT HAS BEEN MADE"
        11320    PRINT " STOP CALCULATIONS WITH A CARRIAGE RETURN "
        11330    PRINT "J THE CALCULATIONS ASSUME A STRAIGHT LINE, AND"
        11340    PRINT "USE THE LEAST SQUARES PARAMETERS."
        11345    Z=1
        11350    IF W9=0 THEN 11380
```

```
          11360      PRINT "JCALCULATE X FROM Y (1) OR Z (2)?"
          11370      INPUT Z
+++1+++   11380      PRINT "JLIST ON SCREEN (1) OR PRINTER (2)?";
          11390      INPUT I
          11400      IF I=2 THEN 11430
          11410      Q9=32
          11420      GO TO 11440
+++1+++   11430      Q9=41
          11435      PRINT @Q9:"LIJJ";S$;"JJJ"
+++1+++   11440      IF Z=1 THEN 11490
          11450      A3=A5
          11460      B1=B3
          11470      Z$="Z"
          11480      GO TO 11520
+++1+++   11490      Z$="Y"
          11500      A3=A6
          11510      B1=B4
+++2+++   11520      PRINT "INPUT ";Z$;" :";
          11530      INPUT G$
          11540      IF G$="" THEN 11730
          11550      G2=VAL(G$)
          11560      IF Z=1 THEN 11590
          11570      IF P8=0 THEN 11590
          11580      GO TO N4+E4 OF 11600,11630,11660,11680
+++2+++   11590      GO TO P1 OF 11600,11630,11660,11680
+++2+++   11600      F2=(G2-A3)/B1
          11610      GO TO 11700
          11620      F2=(G2-A3)/B1
+++2+++   11630      F2=(G2-A3)/B1
          11640      F2=10^F2
          11650      GO TO 11700
+++2+++   11660      F2=(LGT(G2)-A3)/B1
          11670      GO TO 11700
+++2+++   11680      F2=(LGT(G2)-A3)/B1
          11690      F2=10^F2
+++3+++   11700      PRINT @Q9:"I";Z$;"=";G2;"IIX EST=";F2
          11710      PRINT
          11720      GO TO 11520
+++1+++   11730      Q9=32
          11740      END
+++1+++   11750      REM*** ADDING TWO FILES OF DATA (SAME NUMBER OF COLUMNS)***
          11760      PRINT "LI ADDING TWO SETS OF DATA (WITH SAME # OF COLUMNS)"
+++1+++   11770      PRINT "J ADD MAG TAPE FILE TO CURRENT FILE (Y OR N)?";
          11780      INPUT Z$
          11790      IF Z$="Y" THEN 12390
          11800      PRINT "J ADD TWO MAG TAPE FILES (Y OR N)?";
          11810      INPUT Z$
          11820      IF Z$<>"Y" THEN 11770
          11830      PRINT "IJADDITION OF TWO MAG TAPE FILES (SAME # OF COLUMNS)"
          11840      PRINT "JJ INSERT DATA TAPE NOWGGG"
```

```
          11850    PRINT "J INPUT NUMBER OF FIRST FILE:";
          11860    INPUT Q1
          11870    FIND Q1
          11880    READ @33:S1
          11890    READ @33:V1
          11900    DELETE A
          11910    DIM A(S1,V1)
          11920    FOR I=1 TO S1
          11930      FOR J=1 TO V1
          11940        READ @33:A(I,J)
          11950      NEXT J
          11960    NEXT I
          11970    PRINT "JJ INSERT NEXT TAPE, IF NECESSARY GGG"
          11980    PRINT "J INPUT NUMBER OF SECOND FILE:";
          11990    INPUT Q2
          12000    FIND Q2
+++1+++   12010    READ @33:T2,V8
          12020    IF V8=V1 THEN 12050
          12030    PRI "INCOMPATABLE DATA:";V8;" COLUMNS IN FILE 2;";V1;" IN FILE 1"
          12040    GO TO 12380
+++1+++   12050    IF S2=>S1+T2 THEN 12130
          12055    Z=S2-S1
          12060    PRINT "JGGGGGTOO MANY DATA POINTS!"
          12070    PRINT "J ONLY ";Z;" OF ";T2;" WILL BE READ INJ"
          12080    T2=Z
+++1+++   12130    V2=V1+2
          12140    FOR I=S1+1 TO S1+T2
          12150      FOR J=1 TO V1
          12160        READ @33:A(I,J)
          12170      NEXT J
          12180    NEXT I
          12270    S1=S1+T2
          12280    PRINT "INPUT NEW DATA IDENTIFICATION (<72 CHARACTERS)"
          12290    INPUT S$
          12300    FOR I=1 TO S1
          12310      PRINT I;"        ";
          12320      FOR J=1 TO V1
          12330        PRINT A(I,J);"      ";
          12340      NEXT J
          12350      PRINT
          12360    NEXT I
          12370    DELETE Q
+++1+++   12380    END
+++1+++   12390    REM *** ADDITION OF MAG TAPE DATA TO CURRENT DATA***
          12400    PRI "JIADDITION OF MAG TAPE DATA TO CURRENT DATA(";V1;" COLUMNS)"
          12410    PRINT "JJINSERT DATA TAPE NOWGGG"
          12420    PRINT "JINPUT FILE NUMBER:";
          12430    INPUT Q1
          12440    FIND Q1
          12450    GO TO 12010
```

```
            12460    END
+++1+++     12470    REM ***REPEAT PLOT ***
            12480    PRINT "LIREPEAT THE LAST  PLOT"
            12490    PRINT "JJTHE PLOT WILL BE IDENTICAL TO THE LAST PLOT;"
            12500    PRINT "  ONLY THE SIZE, SYMBOL AND OUTPUT DEVICE CAN BE CHANGED"
            12510    PRINT "JJ CONFIRM IDENTICAL PLOT NEEDED (Y OR N):";
            12520    INPUT Z$
            12530    P9=0
            12540    IF Z$<>"Y" THEN 3650
            12550    IF H6<>2 THEN 12570
            12560    H6=3
+++1+++     12570    GO TO 4460
            12580    END
+++1+++     12590    REM ***PLOTTING Z AXIS***
            12600    GOSUB E4+1 OF 12860,12860,12610

---1---     12610    REM ***LOG AXIS AND TIC MARKS FOR Z AXIS
            12620    WINDOW X1,X2,W1,W2
            12630    T7=W3
            12640    T9=-T9
            12650    MOVE @Q9:X2,W1
            12660    FOR I=1 TO T7
            12670      Z8=0
            12680      FOR J=2 TO 10
            12690        Z9=LGT(J)
            12700        RDRAW @Q9:T8,Z9-Z8
            12710        RDRAW @Q9:T9,T8
            12720        RDRAW @Q9:-T9,T8
            12730        Z8=Z9
            12740      NEXT J
            12750    NEXT I
            12760    REM *** NUMBERING THE Z AXIS
            12770    PO=W1
            12780    FOR I=0 TO W3
            12790      MOVE @Q9:X2,W1+T
            12800      PRINT @Q9:" 10B";PO
            12810      PO=PO+1
            12820    NEXT I
            12830    WINDOW X1,X2,Y1,Y2
            12840    GO TO 4730
            12850    END

---2---     12860    REM*** DRAW CARTESIAN AXIS AND TIC MARKS FOR Z
            12870    WINDOW Y1,X2,W1,W2
            12880    MOVE @Q9:X2,W1
            12890    T7=W3
            12900    T9=-T9
            12910    Z8=0
```

```
          12920     Z9=(W2-W1)/10
          12930     FOR J=1 TO 10
          12940       RDRAW @Q9:T8,Z9
          12950       RDRAW @Q9:T9,T8
          12960       RDRAW @Q9:-T9,T8
          12970     NEXT J
          12980     REM ***NUMBERING Z AXIS (CARTESIAN)
          12990     T9=X2
          13000     PO=W1
          13010     Z9=(W2-W1)/5
          13020     A9=INT(LGT(ABS(W1)+ABS(Z9))+1.0E-8)
          13030     FOR I=1 TO 6
          13040       MOVE @Q9:T9,PO
          13050       P6=PO/10^A9
          13060       IF W1=>0 THEN 13080
          13070       PRINT @Q9:' ';
+++1+++   13080       PRINT @Q9: USING '-2D.2D':P6
          13090       PO=W1+Z9*I
          13100     NEXT I
          13110     WINDOW X1,X2,Y1,Y2
          13120     GO TO 4730
+++1+++   13130     REM ***TITLE FOR Z AXIS
          13140     MOVE @Q9:X2,Y1+Y3/2
          13150     IF P1=3 OR P1=4 THEN 13180
+++1+++   13180     PRINT @Q9:'          ';
          13190     SET DEGREES
          13200     PRINT @Q9,25:-90
          13210     IF P9=0 THEN 13260
          13220     IF A9=0 THEN 13260
          13230     P$=STR(A9)
          13240     W$=W$&' *10K'
          13250     W$=W$&P$
+++2+++   13260     FOR J=1 TO LEN(W$)/2
          13270       PRINT @Q9:'H';
          13280     NEXT J
          13290     PRINT @Q9:W$
          13300     PRINT @Q9,25:0
          13310     GO TO 6300
          13320     END
+++1+++   13330     REM **SYMBOL SELECTION FOR X,Z POINTS
          13340     PRINT 'J ENTER SYMBOL NUMBER FOR X,Z POINTS:';
          13350     INPUT A4
          13360     GO TO A4 OF 13370,13390,13410,13430,13450,13470,13490
+++1+++   13370     A$='TRIANGLE'
          13380     GO TO 13500
+++1+++   13390     A$='SQUARE'
          13400     GO TO 13500
+++1+++   13410     A$='DIAMOND'
          13420     GO TO 13500
+++1+++   13430     A$='`+`'
```

```
          13440   GO TO 13500
+++1+++   13450   A$="``X``"
          13460   GO TO 13500
+++1+++   13470   A$="``*``"
          13480   GO TO 13500
+++1+++   13490   A$="POINT"
+++6+++   13500   PRINT "ENTER SYMBOL NUMBER FOR X,Y POINTS:";
          13510   GO TO 7310
          13520   END
+++1+++   13530   REM *** DRAWING X,Z POINTS
          13535   IF Q3=0 OR Q4=0 THEN 14110
          13540   B4=B1
          13550   A6=A3
          13560   WINDOW X1,X2,W1,W2
          13580   W5=4
          13590   M2=W3/100
          13600   M7=M4
          13610   M4=A4
          13620   FOR I=Q3 TO Q4
          13630     X6=X(I)
          13640     IF X(I)>X8 OR X(I)<X9 THEN 13690
          13650     L=W(I)
          13660     G1=0
          13670     MOVE @Q9:X6,L
          13680     GOSUB 9360
+++1+++   13690   NEXT I
          13700   REM ***CALC OF LEAST SQUARES
          13710   P=0
          13720   G=0
          13730   F=0
          13740   F1=0
          13750   N1=0
          13760   FOR I=Q3 TO Q4
          13770     X6=X(I)
          13780     IF X(I)<X9 OR X(I)>X8 THEN 13860
          13790     Y6=W(I)
          13800     P=P+X6*Y6
          13810     G=G+Y6
          13820     F=F+X6
          13830     F1=F1+X6^2
          13840     N1=N1+1
          13850     G1=G1+Y6^2
+++1+++   13860   NEXT I
          13870   HOME
          13880   PRINT "JJJJJJ"
          13890   GO TO 5100
+++1+++   13900   REM PRINT OUT OF COEF FOR X,Z DATA
          13910   PRINT "JJJJJJ"
          13912   IF P8=1 THEN 13920
          13914   GO TO P1 OF 13930,13960,13990,14020
```

```
+++1+++   13920     GO TO N4+E4 OF 13930,13960,13990,14020
+++2+++   13930     PRINT USING 13940:A3,B1
          13940     IMAGE 'Z=',+4E,X,+4E,'*X'
          13950     GO TO 14040
+++2+++   13960     PRINT USING 13970:A3,B1
          13970     IMAGE 'Z=',+4E,X,+4E,'* LOG X'
          13980     GO TO 14040
+++2+++   13990     PRINT USING 14000:A3,B1
          14000     IMAGE 'LOG Z=',+4E,X,+4E,'* X'
          14010     GO TO 14040
+++2+++   14020     PRINT USING 14030:A3,B1
          14030     IMAGE 'LOG Z=',+4E,X,+4E,'* LOG X'
+++3+++   14040     PRINT 'COEF OF DETERMINATION (R^2)= ';R2
+++1+++   14050     WINDOW X1,X2,Y1,Y2
          14060     M2=Y3/100
          14070     B3=B1
          14080     A5=A3
          14090     M4=M7
          14100     W5=1
+++1+++   14110     GO TO 5520
          14120     END
+++1+++   14130     REM ***ROUTINE FOR Z AXIS DIFFERENT FROM Y AXIS (P8=1)***
          14140     PRINT 'JCARTESIAN (1) OR LOG (2) COORDINATES ON Z AXIS?';
          14150     INPUT E4
          14160     IF E4=2 THEN 14180
          14170     E4=0
+++1+++   14180     IF P1=2 OR P1=4 THEN 14210
          14190     N4=1
          14200     GO TO 14220
+++1+++   14210     N4=2
+++1+++   14220     IF E4=2 THEN 14310
          14230     FOR I=1 TO S1
          14240        W(I)=A(I,W7)
          14250     NEXT I
          14260     PRINT 'INPUT BOUNDARIES FOR Z(MIN, MAX):';
          14270     INPUT W1,W2
          14280     W3=W2-W1
          14290     DEF FNW(V)=V
          14300     GO TO 4170
+++1+++   14310     I=1
+++1+++   14320     IF I=S1+1 THEN 14390
          14330     IF A(I,W7)=0 THEN 14360
          14340     I=I+1
          14350     GO TO 14320
+++1+++   14360     PRINT 'GGGGGGGERROR: A ZERO VALUE HAS BEEN FOUND IN THE Z DATA'
          14370     PRINT '  IT MUST BE REMOVED BEFORE A LOG PLOT CAN BE MADE'
          14380     GO TO 1100
+++1+++   14390     FOR I=1 TO S1
          14400        W(I)=LGT(A(I,W7))
          14410     NEXT I
```

```
+++1+++   14420    PRINT "JINPUT MINIMUM BOUNDARY FOR Z AND NO. OF CYCLES:";
          14430    INPUT W1,W3
          14440    A9=0
          14450    IF W1>0 THEN 14480
          14460    PRINT "MINIMUM Z MUST BE GREATER THAN ZERO GGGGJ"
          14470    GO TO 14420
+++1+++   14480    W1=W1+0.01
          14490    W1=INT(LGT(W1))
          14500    W2=W1+W3
          14510    DEF FNW(V)=LGT(V)
          14520    GO TO 4190
+++1+++   14530    REM ***DASHED LINES ON A PLOT***
          14540    PRINT "LIDASHED LINES ON PLOTJ"
          14550    PRINT " 1. NO DASHED LINE"
          14560    PRINT " 2. DASHED LINE ON X,Y PLOT"
          14570    IF W9=0 THEN 14590
          14580    PRINT " 3. DASHED LINE ON X,Z PLOT"
+++1+++   14590    PRINT " JJ ENTER SELECTION NUMBER:";
          14600    INPUT N8
          14610    GO TO N8 OF 14620,14640,14660
+++1+++   14620    E$="SET OFF"
          14630    GO TO 6740
+++1+++   14640    E$="SET ON X,Y PLOT"
          14650    GO TO 14670
+++1+++   14660    E$="SET ON X,Z PLOT"
+++1+++   14670    PRINT "JJSELECT DASH PATTERN (FOR PLOTTER ONLY) -"
          14680    PRINT "I1. ---------"
          14690    PRINT "I2. _._._._._"
          14700    PRINT "I3. .........."
          14710    PRINT "JINPUT SELECTION:";
          14720    INPUT N5
          14730    REM ***INPUTING THE EQUATION FOR THE DASHED LINE
          14740    PRINT "JINPUT THE EQUATION IN LINE 14890"
          14750    PRINT "INSTRUCTIONS"
          14760    PRI "I1. THE EQUATION IS WRITTEN IN TERMS OF R(I), (X COMPONENT)
          14770    PRINT "I    AS A FUNCTION OF N(I), (THE Y COMPONENT)"
          14780    PRINT "I2. ONLY N(I) SHOULD BE ON THE LEFT SIDE OF THE EQUATION"
          14790    PRINT "I3. RECALL LINE 14890 AND INPUT THE EQUATION"
          14800    PRINT "I4. THEN PRESS USER KEY #18"
          14810    END
---------------------------------------------------------------------------
----1---  14820    REM ***PLOTTING THE DASHED LINE ***
          14830    DELETE N,R
          14840    DIM N(S1),R(S1)
          14850    N=0
          14860    R=0
          14870    FOR I=1 TO S1
          14880      R(I)=A(I,Y7)
          14890      N(I)=R(I)*0.01
```

```
          14900    NEXT I
          14910    IF N8=2 THEN 14940
          14920    WINDOW X1,X2,W1,W2
          14930    GO TO 14950
+++1+++   14940    WINDOW X1,X2,Y1,Y2
+++1+++   14950    IF P8=0 THEN 14970
          14960    GO TO N4+E4 OF 14980,15020,15060,15100
+++1+++   14970    GO TO P1 OF 14980,15020,15060,15100
+++2+++   14980    REM***CARTESIAN
          14990    DEF FNR(V)=V
          15000    DEF FNN(V)=V
          15010    GO TO 15140
+++2+++   15020    REM***SEMILOG ON X
          15030    DEF FNN(V)=V
          15040    R=LGT(R)
          15050    GO TO 15140
+++2+++   15060    REM *** SEMILOG ON Y
          15070    DEF FNR(V)=V
          15080    N=LGT(N)
          15090    GO TO 15140
+++2+++   15100    REM*** LOG-LOG
          15110    R=LGT(R)
          15120    N=LGT(N)
          15130    REM***DRAWING DASHED LINE ***
+++3+++   15140    IF Q9=1 THEN 15220
          15150    MOVE @Q9:R(1),N(1)
          15160    DASH 85
          15170    DRAW @Q9:R,N
          15180    DASH 0
          15190    WINDOW X1,X2,Y1,Y2
          15200    RETURN
          15210    END
+++1+++   15220    REM DASHED LINE FOR PLOTTER
          15230    GOSUB N5 OF 15330,15380,15430
          15240    MOVE @Q9:R(1),N(1)
          15250    FOR I=1 TO S1
          15260       DRAW @Q9:R(I),N(I)
          15270       MOVE @Q9:R(I),N(I)
          15280    NEXT I
          15290    PRINT @1,32:'BL';0
          15300    WINDOW X1,X2,Y1,Y2
          15310    RETURN
          15320    END
----------------------------------------------------------------
---1---   15330    REM*** ------- ****
          15340    PRINT @1,32:'BL';1
          15350    PRINT @1,32:'BD';1,1,1,1,1,1,1,1,1
          15360    PRINT @1,32:'BS';10
          15370    RETURN
```

```
---1---  15380    REM*** -,-,-,-,***
         15390    PRINT @1,32:'BL';1
         15400    PRINT @1,32:'BD';1,1,0,1,1,1,0,1,1,1,0,1,1
         15410    PRINT @1,32:'BS';10
         15420    RETURN

---1---  15430    REM*** ,,,,,,,,,***
         15440    PRINT @1,32:'BL';1
         15450    PRINT @1,32:'BD';0,0,0,1,0,1,0,1,0,1,0,1,0
         15460    PRINT @1,32:'BS';5
         15470    RETURN
         15480    END

---1---  15490    REM    POINTER FUNCTION
         15500    VIEWPORT 10,95,0,30
         15510    WINDOW 0,20,-0.6,5
         15520    MOVE 0,0
         15530    DRAW 0,2.5
         15540    DRAW 20,2.5
         15550    DRAW 20,0
         15560    DRAW 0,0
         15570    FOR I=1 TO 5
         15572       MOVE 0,I/2
         15574       DRAW 20,I/2
         15576    NEXT I
         15578    VIEWPORT 20,85,80,110
         15580    WINDOW 0,20,-0.5,5
         15582    MOVE 0,0
         15584    DRAW 0,2.5
         15586    DRAW 20,2.5
         15588    DRAW 20,0
         15590    DRAW 0,0
         15592    FOR I=1 TO 5
         15594       MOVE 0,I/2
         15596       DRAW 20,I/2
         15598    NEXT I
         15610    VIEWPORT 5,100,0,98
         15620    WINDOW X1-0.23*X3,X2+0.15*X3,Y1-0.54*Y3,Y2
         15630    H=0
+++1+++  15640    L$=''
         15650    H4=1
         15660    I=1
         15670    CHARSIZE 3
+++3+++  15680    POINTER H1,H2,H$
         15690    MOVE @Q9:H1,H2
         15700    IF H$='?' THEN 16320
```

```
           15710    IF H$="8" THEN 15810
           15720    IF H$="0" THEN 15840
           15730    IF H$="1" THEN 16030
           15740    IF H$="2" THEN 16070
           15750    IF H$="3" THEN 16110
           15760    IF H$="4" THEN 16150
           15770    IF H$="5" THEN 16190
           15780    IF H$="6" THEN 16230
           15790    IF H$="7" THEN 16270
           15800    GO TO 15680
+++1+++    15810    REM H$="8",   CORRECT LAST ENTRY
           15820    IF I=1 THEN 15640
           15830    I=I-1
           15840    MOVE @Q9:H(I,3),H(I,4)
           15850    GO TO 15680
+++1+++    15860    REM H$="0", WRITING ONLY, NO SYMBOL
           15870    H(I,1)=0
+++7+++    15880    H(I,4)=H1
           15890    H(I,5)=H2
           15900    IF H$="0" THEN 15940
           15910    H(I,2)=H4
           15920    H(I,3)=0
           15930    GO TO 16010
+++1+++    15940    PRINT @Q9:"";
           15950    INPUT K$
           15960    H3=LEN(K$)
           15970    L$=L$&K$
           15980    H(I,2)=H4
           15990    H(I,3)=H3
           16000    H4=H4+H3
+++1+++    16010    I=I+1
           16020    GO TO 15680
+++1+++    16030    REM H$="1",   TRIANGLE SYMBOL
           16040    H(I,1)=1
           16050    GOSUB 9390
           16060    GO TO 15880
+++1+++    16070    REM H$="2", SQUARE
           16080    H(I,1)=2
           16090    GOSUB 9450
           16100    GO TO 15880
+++1+++    16110    REM H$="3" ,DIAMOND
           16120    H(I,1)=3
           16130    GOSUB 9520
           16140    GO TO 15880
+++1+++    16150    REM H$="4",   +
           16160    H(I,1)=4
           16170    GOSUB 9590
           16180    GO TO 15880
+++1+++    16190    REM H$="5",   X
           16200    H(I,1)=5
```

```
            16210    GOSUB 9650
            16220    GO TO 15880
+++1+++     16230    REM H$='6',   *
            16240    H(I,1)=6
            16250    GOSUB 9710
            16260    GO TO 15880
+++1+++     16270    REM H$='7', DOT
            16280    H(I,1)=7
            16290    GOSUB 9760
            16300    GO TO 15880
            16310    END
+++1+++     16320    H7=I
            16330    VIEWPORT 20,85,34,99
            16340    WINDOW X1,X2,Y1,Y2
            16350    CHARSIZE 2
            16360    RETURN
            16370    END

---1---     16380    REM  PRINT LEGEND AND TITLE
            16390    CHARSIZE 3
            16400    VIEWPORT 5,100,0,97
            16410    WINDOW X1-0.23*X3,X2+0.15*X3,Y1-0.54*Y3,Y2
            16420    IF Q9=32 THEN 16450
            16430    VIEWPORT 2,97,15,115
            16440    WINDOW X1-0.23*X3,X2+0.15*X3,Y1-0.54*Y3,Y2
+++1+++     16450    FOR I=1 TO H7
            16460       MOVE @Q9:H(I,4),H(I,5)
            16470       IF H(I,1)=0 THEN 16490
            16480       GOSUB H(I,1) OF 9390,9450,9520,9590,9650,9710,9760
+++1+++     16490       PRINT @Q9:' ';
            16500       K$=SEG(L$,H(I,2),H(I,3))
            16510       PRINT @Q9:K$
            16520    NEXT I
            16530    VIEWPORT 20,85,34,99
            16540    WINDOW X1,X2,Y1,Y2
            16550    CHARSIZE 2
            16560    RETURN
            16570    END
```

DATACOM 1220 PRINTER SET-UP   Appendix V

1. Turn the Datacable knob to position 1 (4054).
2. Install 8½ x 11" paper in printer.
3. Turn the printer parameters as follows:
    a. Depress the SETUP key. Keep it depressed while doing steps b-d
    b. set M to 1
    c. set W to 3
    d. for 8½ x 11" paper, set F to 66
4. Manually position the top of the paper so it is ~ ¼" above the printer head.

The settings below are for an 8½ x 11" sheet of paper, as shown in Figure 1 of the text.

1) Turn the Plotter ON
2) Position the paper with the bottom right hand corner at the arrow mark on the platten. Push Media Change button to hold the paper in place.
3) Install a fiber tip pen in the Pen 1 holder.
4) Set the pullout Parameter Entry card as follows:

a.	Parameter Set Up Select	Set Up 2
b.	Media Form	Sheet
c.	Initial Page Size	A
d.	Initial Page Format	Drafting
e.	Page Orientation	Vertical
f.	Initial Aspect Ratio	Full Page
g.	Initial Axis Orientation	#2 X ↓→Y
h.	Line Quality	Enhanced 2
i.	Pen Parameter Access	Pen 1
j.	Pen Type	Fiber Tip
k.	Pen Pressure	5 gm
l.	Pen Velocity	Full speed axial
m.	Alpha Character Quality	Enhanced
n.	Interface Select	#2 (GPIB)

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13. ABSTRACT

A BASIC plotting routine for the Tektronix 4054 terminal and 4663 plotter has been developed. It is named PLOT. The program is capable of plotting in a variety of coordinate systems - Cartesian, semilog on X, semilog on Y or log-log. Two separate Y axes can be used. The user can input the axes boundaries, axes titles, the block of data to be plotted, legends for the data, and a figure caption. Model equations can be represented by dashed lines on the plot. The program will accommodate up to 100 data sets, and a total of seven data columns. The data can be manipulated by changing data points or sets, adding sets and columns, deleting sets or columns, sorting data in a column, generating columns from existing data and adding two data files together. This report is a working manual for the PLOT program.

DSIS
10-410

KEY WORDS

BASIC program
Tektronix 4054 terminal
plotting routine
log-log plots
semi-log plots
cartesian plots

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13. ABSTRACT Enter an abstract giving a brief and factual summary of the document, even though it may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall end with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (TS), (S), (C), (R), or (U).

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